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## MONOGRAPHS OF THE MARINE MOLLUSKS OF THE WESTERN ATLANTIC

VOLUME III  
Numbers 33-39

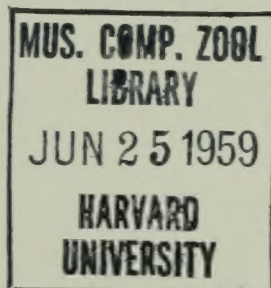
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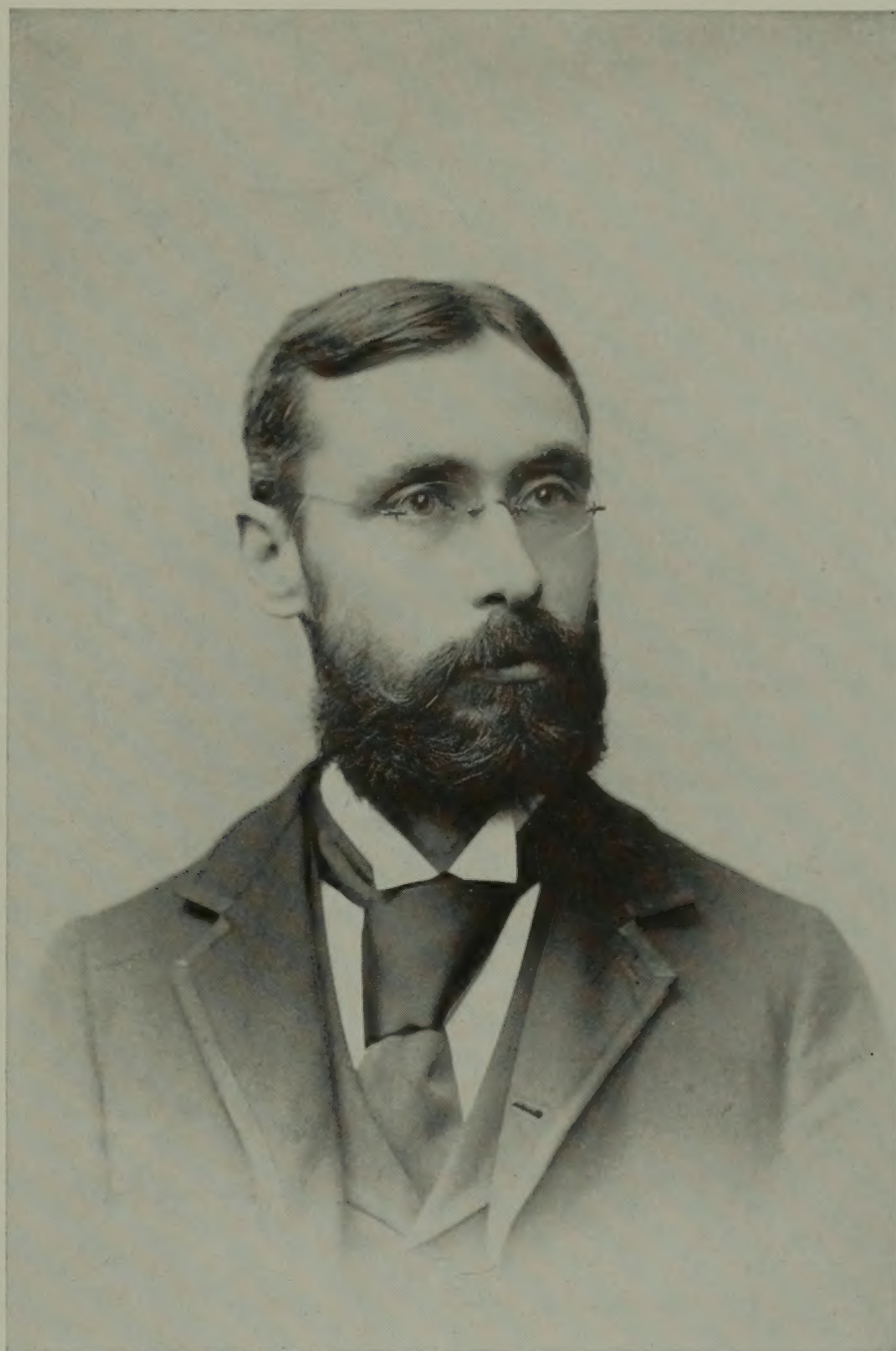
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HENRY A. PILSBRY, 1889





HENRY A. PILSBRY, ABOUT 1900

HENRY A. PILSBRY

December 7, 1862–October 26, 1957

**I**T is our pleasure to dedicate this third volume of *Johnsonia* to Dr. Pilsbry. Though he is perhaps most famous for his work on land mollusks, particularly those of North America, and his revision of the helices, he published many papers on marine mollusks. In fact, his publications in the latter field, though a small part of his total studies, probably exceed those which many workers produce in the course of a lifetime. His main studies on marine mollusks were those done in the first series of the *Manual of*

Conchology which he took over completely beginning with volume 10. The entire series consisted of 17 volumes and covered the cephalopods, chitons, scaphopods and marine gastropods of the world. The volumes on chitons and scaphopods are particularly fine and are classics in the field of malacology. In addition to the Manual, Pilsbry published many separate papers on marine shells, outstanding among these being his Catalogue of the Marine Mollusks of Japan.

Henry A. Pilsbry was born on a farm near Iowa City, Iowa on December 7, 1862. He was educated in the local public schools and the University of Iowa from which he received the degree of Bachelor of Science. In 1900 he received an honorary ScD from the University of Iowa and in 1940 a second honorary degree was conferred upon him by the University of Pennsylvania. Though he worked for a short time for newspapers, publishing houses and as librarian at the Davenport Academy of Sciences, his spare time was always spent in collecting and studying mollusks. His first paper, published in 1882, was on the land and freshwater shells of Iowa City and until he went to the Academy of Natural Sciences, Philadelphia where he inherited the work on the marine series of the Manual of Conchology his interest was entirely in land and freshwater shells.

Dr. Pilsbry joined the staff of the Academy in December 1887 as assistant to George W. Tryon, Jr. With the death of Mr. Tryon the following year, Henry Pilsbry, as a young man of 26, became editor of the two series of the Manual of Conchology and Conservator of the Conchological Section of the Academy. Later, he was given the title of Curator of the Department of Mollusks and Marine Invertebrates. In 1889, he became editor of the *Nautilus* and there are numerous papers on marine mollusks by him in this journal as well as in the publications of the Academy.

Pilsbry's interest in marine animals was not confined to mollusks for he published on brachiopods and barnacles and became the world authority on the latter. He published many papers on this group, the first appearing in 1896; his monograph on the sessile barnacles which appeared in 1916 is still a basic work in this field. Interest in the cirripeds continued throughout his life and at the time of his death he was working on a paper on barnacles.

The continuation of his early interest in paleontology is evidenced by the many studies he made of fossil faunas, many of which were based on marine horizons. He was author of the sections on scaphopods, chitons and gastropods for Zittel's Textbook of Paleontology.

A brief account of Pilsbry's life and a complete list of his papers up through December 1939 was compiled by Dr. H. B. Baker and published by the American Malacological Union in 1940. Following Pilsbry's death, Baker, who had been his associate and close personal friend for many years, wrote a fine, very human and understanding account of the life of this remarkable man (*Nautilus* 71, no. 3, pp. 73-83, January 1958). In this same volume of the *Nautilus*, which was devoted entirely to Pilsbry, there are accounts of his work on Marine Malacology by Jeanne S. Schwengel (pp. 87-89), on Fossil and Marine Mollusca by Axel A. Olsson (pp. 89-94), and his scientific contributions made from 1940 to 1957 were given on pages 104-112.

All branches of Malacology owe a great debt to this man whose keen understanding of species and their relationships has brought order out of chaos in many groups.

—R. D. TURNER

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\* \* \* \*

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We are grateful to a large number of persons who have donated or loaned much of the material upon which our studies were made. All photographs, unless otherwise noted, were made by Frank White, staff photographer for the Biological Laboratories, Harvard University.

\* \* \* \*

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## ERRATA

No. 34, p. 102, last name in key should read *Particoma*

No. 34, p. 145, *Xyloghagus* Meuschen should read *Xylophagus*

## *A Partial Analysis of the Molluscan Fauna of the Western Atlantic*

In the table below, we list only the number of species and their synonyms which have been considered in *Johnsonia* for the Western Atlantic. Species included in *Johnsonia*, but not known to occur in the Western Atlantic, have been excluded from this tabulation.

No single check list has ever been attempted to cover the entire Western Atlantic. Regional check lists have appeared within the past several years, such as Johnson's Marine Mollusca of the Atlantic Coast from Labrador to Texas, several papers by Carcelles covering Argentina, and a check list by Lange de Morretes for Brasil. To collate these reports and many others which have been published covering much smaller geographic areas would still leave rather large gaps in many coastal regions between Greenland and southern Argentina.

A question frequently asked is "How many species of mollusks are to be found in the Western Atlantic?" We don't know, of course, but we can make an estimate that the molluscan fauna of this area would exceed 6,000 species and subspecies, but probably would not reach 8,000 species and subspecies.

To date, in *Johnsonia*, 438 species and subspecies from this region have been monographed. Though only a fragment of the total number it is sufficiently large to justify a report upon this number of recognized species and their synonyms. The ratio between valid species and the synonyms involved will change with each volume completed. The over-all ratio, however, should remain within fairly narrow limits because the groups covered have included rare as well as common species from a wide variety of habitats belonging to both the bivalves and the gastropods.

The synonyms listed below are those which have been described as "species." Misspellings of names or misidentifications have not been considered as synonyms in this tabulation.

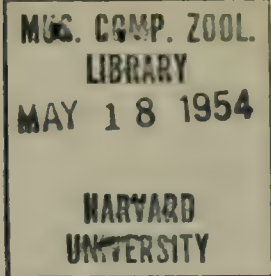
<i>Johnsonia</i>	No. of species	No. of synonyms	ratio
Vol. 1	210	338	1.61
Vol. 2	169	247	1.38
Vol. 3	59	141	2.64
Total	438 species	726 synonyms	1.64

Many regional distribution patterns are beginning to show in our locality records. We have not, as yet, covered enough of the commoner species to be at all certain about the limits of many smaller geographic areas. There are still long stretches of coast line, particularly in Central and South America, from which there is little or no material available in our various museums.

Pages I-VIII published June 26, 1959

# JOHNSONIA

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MAY 17, 1954

PHOLADIDAE

VOL. 3, NO. 33\*

## THE FAMILY PHOLADIDAE IN THE WESTERN ATLANTIC AND THE EASTERN PACIFIC

### PART I—PHOLADINAE

BY

RUTH D. TURNER

The Pholadidae are a family of highly specialized bivalve mollusks adapted for boring into wood, soft rock, shells, peat, hard clay and mud. They are characterized by having accessory plates in addition to the normal bivalve shell, and for this reason were early classified with the barnacles and the chitons in the Multivalva.

#### ECONOMIC IMPORTANCE

As has been pointed out previously (Clench and Turner, 1946), the financial loss due to damage caused by wood-boring mollusks probably exceeds by far the amount realized from the use of mollusks for food and all other purposes. Though the entire family Teredinidae is exceedingly destructive, only a few genera of the Pholadidae are of importance in this respect.

*Martesia* is the most destructive genus in the family as all species in the genus are wood-borers and all may do considerable damage to water front structures. *Martesia striata* Linné is the best known and most destructive species and in some localities such as Cavite, Luzon, Philippine Islands, it may be even more destructive than the Teredinidae. This

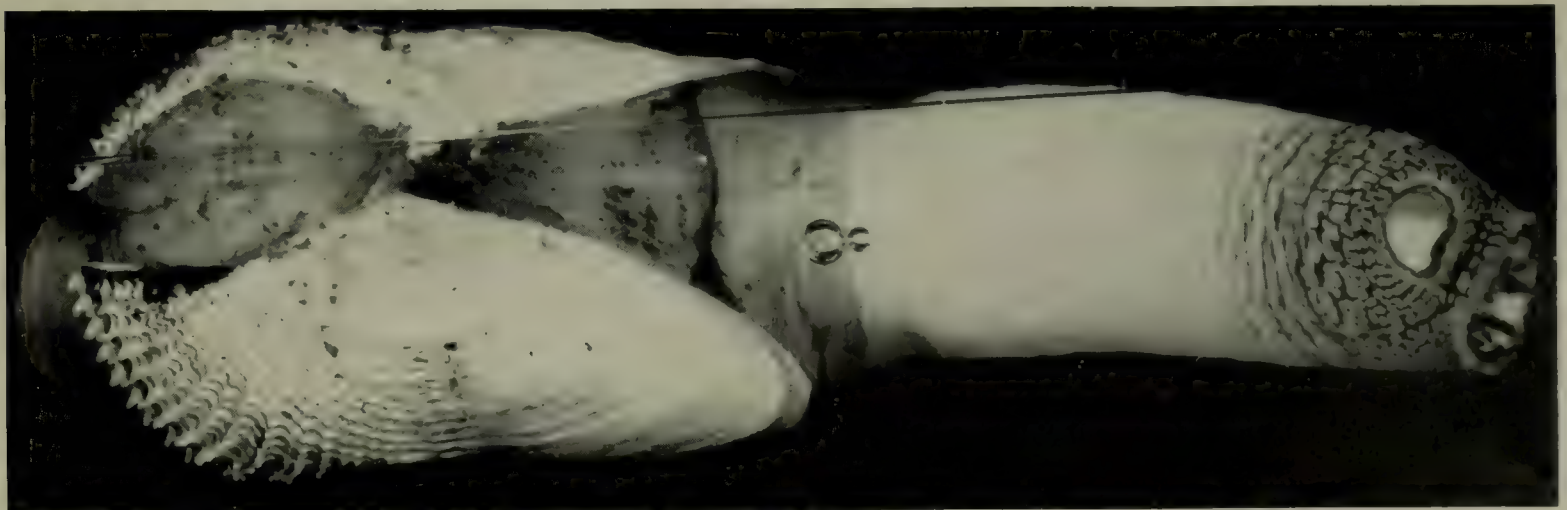


Plate 1. *Zirfaea crispata* Linné, Rye Harbor, New Hampshire (about 2x). Photographed in a test tube under water to show the extended siphons; the external anterior adductor muscle, which is covered only by a thin layer of periostracum; the small mesoplax and the expanded foot.

\* *Johnsonia*, Volume 3, starts with Number 33.

species has been carried nearly all over the world by man and has recently been introduced into Sydney Harbor, Australia where it is doing considerable damage. It is also a problem in San Juan, Puerto Rico and Pearl Harbor, Honolulu.

Species in the genera *Xylophaga* and *Martesia*, though generally wood-borers, have been known to attack underwater cables causing short circuits (Bartsch and Rehder, 1945 and Purchon, 1941). Species in the genus *Xylophaga* are usually found in floating or waterlogged wood. They seldom occur in fixed structures, but an occasional attack may cause considerable damage. They may also be found in considerable numbers in buoy markers and lobster pot floats.

Of the rock-borers, only *Penitella penita* Conrad has been recorded as definitely destructive. At the time of the San Francisco Bay Marine Piling Investigation, it was found that this species had penetrated the concrete jackets of the piling in several localities about Los Angeles, California. They were boring from a height of two feet above mean low water down to the mudline. It was found, however, that they occurred in numbers only in inferior grades of cement.

*Diplothyra smithii* Tryon and *Penitella conradi* Valenciennes are both shell-borers, the former going chiefly into *Ostrea* and the latter into *Haliotis*. Neither appears to do any real harm to its host, though heavily infested shells of *Haliotis* are, of course, useless in the jewelry trade.

Most species of the Pholadidae are not of any real economic importance, except perhaps as their borings may aid in minor changes of the coast line and in the reduction of wood in the sea. A few species are used as food occasionally though none is of commercial value. Most species are too difficult to remove from their burrows and too full of sand to make them worth the effort. *Pholas dactylus* Linné was used for food by the early Romans and according to Jeffreys (1865) it was used both for food and fish bait in Normandy and Dieppe. *Cyrtopleura costata* Linné was at one time sold in the markets in Habana, Cuba but it is too rare to be of commercial value today. Mr. E. P. Chace of California writes that the "wart-necked piddock" makes an excellent chowder—one specimen being sufficient for two people—but the work of digging out the specimen is considerable.

#### NOTES ON ECOLOGY AND DISTRIBUTION

The family Pholadidae is world wide in distribution with most species occurring from the intertidal zone to a depth of perhaps 250 fathoms. Much greater depths have been recorded for some species but it is uncertain whether these specimens were taken dead or alive. A few species appear to be restricted mainly to floating wood and may be considered pelagic. The family as a whole is restricted locally by the specialized habitat required for each group. Species in the genus *Zirfaea* prefer salt marsh peat and stiff mud, while *Penitella* and *Parapholas* bore into much harder shales and sandstones and *Pholas dactylus* Linné may attack gneiss. *Martesia* and *Xylophaga*, as borers, are restricted mainly to wood.

The greatest development of the family appears to be in the Eastern Pacific which has 13 genera including 23 species, while in the Western Atlantic there are only 8 genera with 13 species. There are seldom more than two or three species per genus in a given region and often there is only one. For the genera, *Zirfaea*, *Barnea* and *Pholas*, there are companion species in the Western Atlantic and the Eastern Pacific and it would appear that in the geologic past they were probably one species. The genera *Penitella*,

*Parapholas*, *Pholadidea* and *Chaceia*<sup>1</sup> are not found living in the Western Atlantic so far as is known, but an internal cast of an Eocene (?) fossil taken at Niquero, Oriente, Cuba, would indicate that a representative, probably of the genus *Penitella*, was living in the West Indies at that time. Whitefield (1885) reports a *Parapholas* from the Eocene marls of New Jersey and von Ihering (1907, p. 330) reports a species from the Eocene of Patagonia which he refers to *Martesia* but which on the basis of his figures probably belongs in the genus *Pholadidea*. These genera are now restricted to the Pacific with the exception of *Pholadidea*, one species of which is found in Europe. Only *Zirfaea crispata* Linné and *Barnea truncata* Say are shared by the Western Atlantic and the Eastern Atlantic and it would appear that *B. truncata* Say is probably a fairly recent introduction into West Africa. *Martesia striata* Linné, like many species of *Teredo* and *Bankia*, is often found in European waters, having been carried there in flotsam by the Gulf Stream, but it does not appear to breed in these waters.

The genus *Zirfaea* is restricted to the colder portions of the temperate and the boreal regions of the northern hemisphere and the genus *Talona* is restricted to Africa. All other genera in the family are found both north and south of the equator with the greatest abundance in the subtropical and warm temperate regions. The occurrence of several northern species in Lower California may be explained by the upwelling of cold water at several points along the coast, according to a letter received from J. E. Fitch of the California Fisheries Laboratory, who has also kindly sent us material from that region.

A detailed account of the ecology of *Zirfaea gabbi* Tryon (= *Zirfaea pilsbryi* Lowe) is given by MacGinitie (1935), and J. E. Fitch (1953) gives a brief account of the habitat

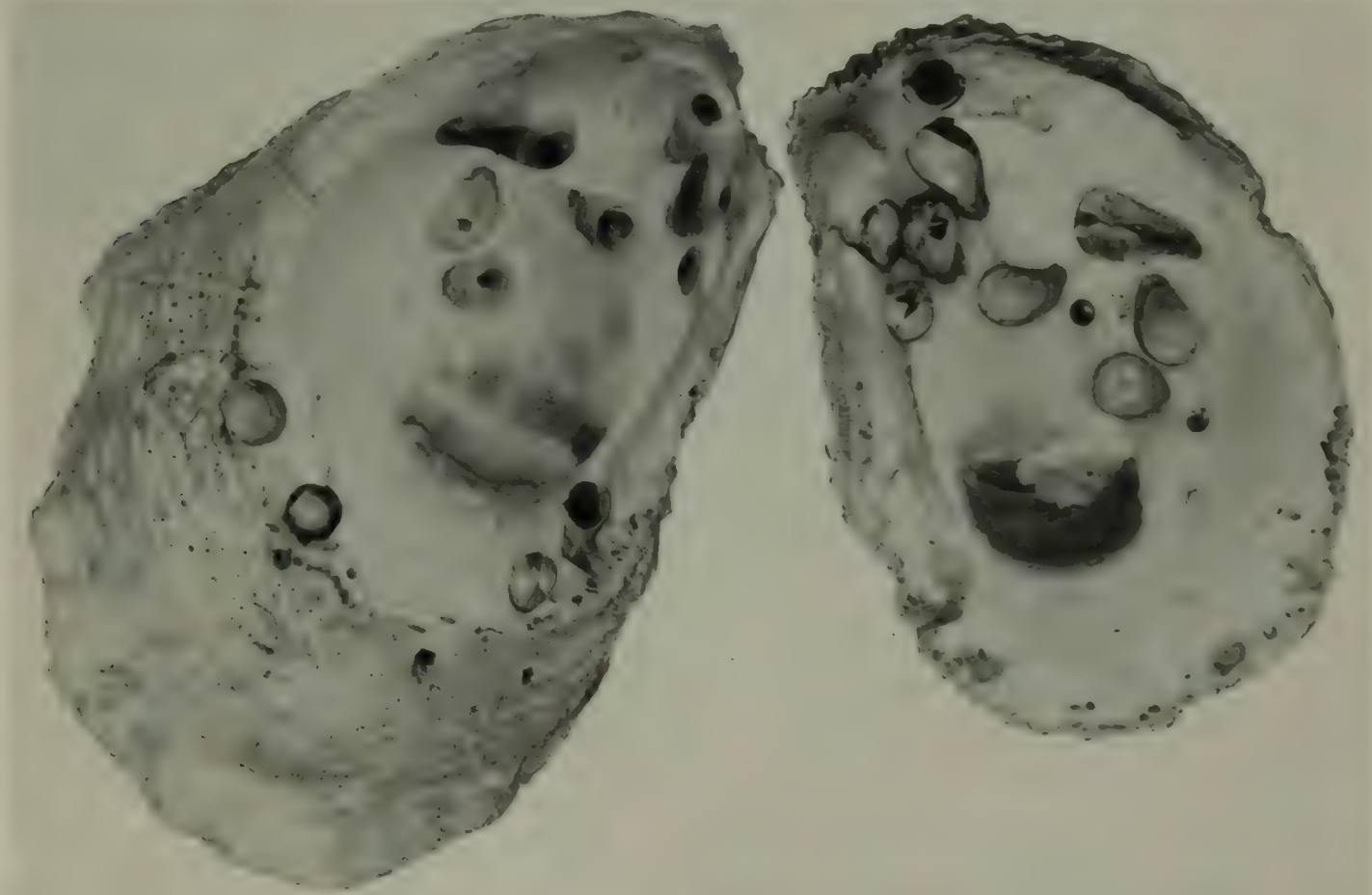


Plate 2. *Diplothyra smithii* Tryon. A specimen of *Crassostrea virginica* Linné split lengthwise showing a heavy infestation of *D. smithii* Tryon. Chesapeake Bay, Maryland (about  $1\frac{1}{3}x$ ).

<sup>1</sup> This new genus will be described in the second part of this study.

and distribution of five species of California pholads. Scattered observations by numerous authors such as Dall, Verrill, Morse and others are noted under the species concerned.

#### NOTES ON THE LIFE HISTORY OF THE PHOLADIDAE

Very little is known concerning the life history of the various species of this family. No one species has been completely studied, but varying phases of several species have been worked out and reported upon. Sigerfoos (1894) worked out the early embryology

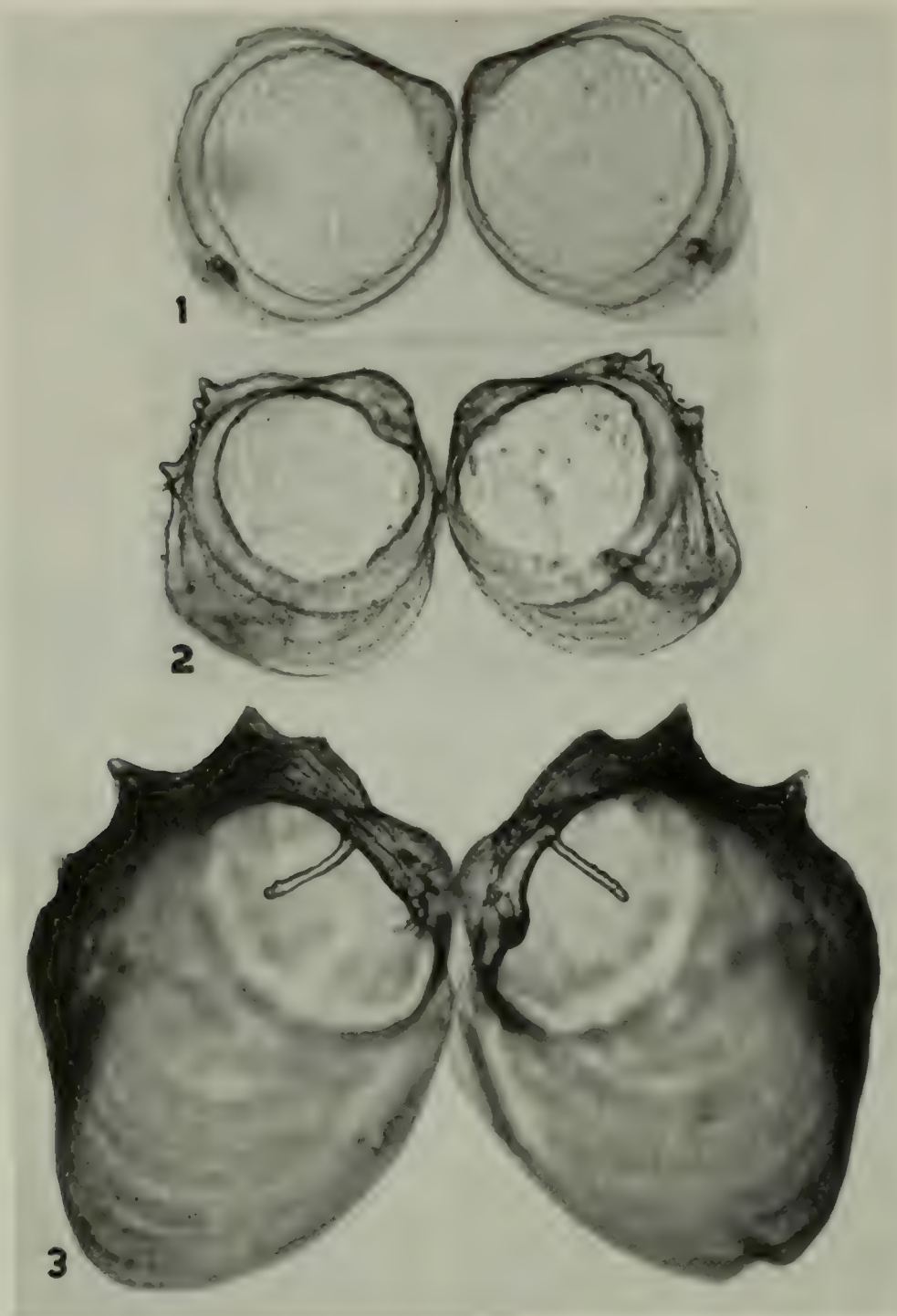


Plate 3. *Zirfaea crispata* Linné (young spat).<sup>1</sup> Fig. 1. At the time of settlement. Fig. 2. With first row of imbrications which are produced immediately after settlement. Fig. 3. With first row of imbrications well developed and showing the beginning of the elongation of the posterior slope and the production of the apophyses (all about 100x).

<sup>1</sup> All figures from C. M. Sullivan 1948, Bivalve Larvae of Malpeque Bay, P. E. I., Fisheries Research Board of Canada, Bulletin 77. We are grateful to Dr. J. C. Medcof and Dr. C. M. Sullivan for the loan of the negatives for these prints.

of *Barnea truncata* Say which he studied at Beaufort, North Carolina. In this species the sexes are separate, fertilization is external and the eggs and sperm are extruded into the water, usually during a few weeks in late April and early May. The eggs are small and rather transparent. Development is so rapid that on warm days the larvae are free-swimming within three hours after fertilization.

According to Bouchard-Chantereaux (1879) fertilization in *Zirfaea* is internal and the young are ejected from the mantle cavity of the adult in the early veliger stage. At Malpeque Bay, Prince Edward Island, Sullivan (1948) found the mature veliger larvae of *Zirfaea crispata* Linné in plankton hauls, from the middle of June to mid-July, when the temperature of the water ranged from 15° to 22° C. She described and figured the larvae and the young spat. Her figures, which we reproduce, show that the apophyses do not develop until the time of settlement. The embryonic shell is about 0.14 mm. in length and nearly circular in outline, with a straight hinge line. Thorson (1946) also illustrates the veliger larvae of this species and he states that in the Sound off Helsingör, Denmark, the larvae are found in the plankton from June through February with the greatest abundance in September.

It has been shown experimentally by Thorson (1946) that the larvae of *Zirfaea crispata* Linné, like those of many marine bottom invertebrates, are able to select actively the substratum on which they settle. He states that in experimental bottles "metamorphosing stages of *Zirfaea crispata* Linné were found in numbers boring into cork floats and only there." He believes that probably most pelagic larvae can delay metamorphosis for a short period of time if they are not on a suitable substratum and he further concludes that even if the current on the bottom is slow this delay would allow for increased survival and dispersal. Though neither Dr. Sullivan nor Dr. Thorson mentioned the attachment of the young spat by a single byssus thread at the time of settlement, such is probably the case. The production of a single byssus in the Teredinidae is well known and our observations would seem to bear this out for *Zirfaea*. Newly settled spat in a test-board submerged at Beverly, Massachusetts were observed to have constructed a small conical covering of cemented wood scrapings for protection during the last stages of metamorphosis. This has also been observed in the Teredinidae, and at this time the young shipworms attach themselves by a single byssus thread, probably to prevent being moved about by the currents. It was also observed on this test-board that the young *Z.*

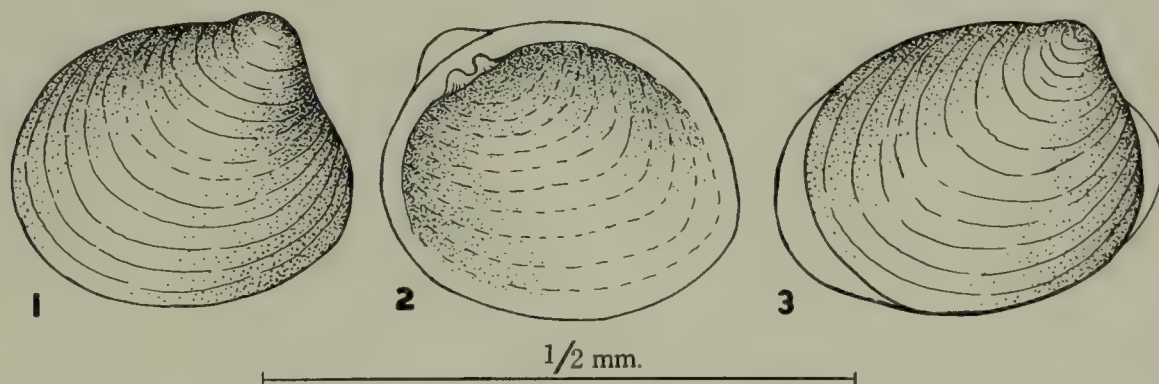


Plate 4. Prodissoconch of *Xylophaga atlantica* Richards. Fig. 1. External view of valve showing marked concentric growth lines. Fig. 2. Internal view of valve showing the two pronounced hinge teeth. Fig. 3. Specimen in the late veliger stage showing the beginning of the elongation of the shell. All specimens taken from the mantle cavity of a preserved specimen which had been taken by the *Albatross* at station 2550, about 160 miles east of Barnegat Bay, New Jersey.

*crispata* settled only on the horizontal upper surface of the board. Though *Zirfaea* usually are not wood-borers, they are occasionally found in waterlogged wood but their presence in a test-board is most unusual.

On the basis of material which has been available for study it appears that fertilization in *Xylophaga dorsalis* Richards is internal and the young are retained within the parent until the late veliger stage and time for settlement. The accompanying plate shows the shell of the young taken from a preserved adult specimen. Thus it would appear that in the Pholadidae as in the Teredinidae ovoviviparity is at best of no more than generic value taxonomically.

Moore (1947) states that the adults of *Martesia striata* Linné are alternating hermaphrodites and Purchon (1941) records the same for *Xylophaga dorsalis* Turton. In addition Purchon discusses the presence of an accessory genital organ in *Xylophaga* and the storage of spermatozoa in an organ which he terms a "vesicula seminalis." This he believes would allow for self-fertilization, a condition which would be of distinct advantage for a species living in isolated colonies, usually in floating or waterlogged wood as is the case with *Xylophaga*.

The rate of growth undoubtedly varies greatly in all members of the Pholadidae, though we have specific data only on such economic species as *Martesia striata* Linné and *Martesia cuneiformis* Say. Once established in their burrows, the rate of growth depends largely upon the hardness of the substratum and the amount of crowding. Test-board records show that specimens may produce a callum in less than a month and when the shell is only 4 mm. in length. Such specimens, generally termed stenomorphs, may continue to live for some time and are capable of producing large numbers of eggs. Under most favorable conditions a specimen may reach 45 mm. in length before producing a callum and may remain in an active state for several months. Specimens from test-boards at San Juan, Puerto Rico had reached a length of 40 mm. in six months and at Bahía, Brasil, specimens of *Martesia cuneiformis* Say taken from a board submerged on May 3, 1945 and removed on June 2, 1945 had reached a length of 11.5 mm.

The average length of life for any one species of pholad, the breeding age or the number of eggs produced, and the duration of the free-swimming larval life are questions still unanswered.

Additional notes on life history and habits, if known, are included in "Remarks" under the individual species.

#### METHODS OF BORING

Since early times scientists have argued over the method by which the various members of the Pholadidae bore. Species of the genera *Pholas*, *Parapholas*, *Penitella*, *Diplothyra* and *Zirfaea* bore into substrata varying in hardness from that of stiff clay to limestone, shale, gneiss and shells such as *Haliotis* and *Ostrea*. Interesting and rather amusing accounts of the various theories of the early 1800's are given by G. Johnston (1850), Forbes and Hanley (1853) and J. G. Jeffreys (1865). Included in their accounts are the arguments supporting theories that boring was accomplished by means of an acid, that the foot did the boring using imbedded siliceous spicules and that the shell was the tool. Buonanni (1684) was the first to believe that the shell was the instrument of boring and Osler (1864), hoping to settle the argument between those who thought boring was accomplished by acid and those who believed in the mechanical theory, spent considera-

ble time observing living animals. He presented a rather detailed paper on his views that boring was mechanical, the shell being used as a tool. The arguments continued, however, and Cailliaud (1855-1857), one of the most ardent of the researchers in this field, wrote numerous papers on the methods of perforation of rocks by *Pholas*. Dubois (1892, p. 34) believed that the siphons alone were responsible for the boring, stating that the musculature of the siphons was sufficient to turn the animal completely around in its burrow. This would mean that the animal was boring like an auger. The action of the foot with the use of sand grains is the theory put forth by Smith (1894) but this could not explain the wood-borers. A rather comprehensive account of the boring mechanisms of several forms that occur in Puget Sound is given by F. E. Lloyd (1887). He goes into particular detail on the musculature of *P. penita* Conrad, showing that in forms which have a ventral adductor muscle, the anterior adductor muscle is divided into two parts. The anterior portion, which he terms the accessory anterior adductor, opposes the posterior adductor muscle. The contraction of the accessory anterior adductor muscle closes the valves anteriorly and opens them posteriorly. The posterior portion, which he terms the anterior adductor muscle, opposes the ventral adductor muscle. The contraction of this portion of the muscle spreads the valves apart ventrally and brings them in contact with the sides of the burrow.

The belief that an acid is employed in boring is no longer held today, but many of the other ideas set forth by early workers fit into the complex picture. The summation of all of these theories along with observations made in the laboratory would indicate that the task of boring is not accomplished by any one organ alone. The shell may be considered the tool which is manipulated by the adductor muscles and is aided by the foot, siphons, mantle, water, and accessory sand grains. An exact procedure does not hold true for all members of the group and even appears to vary somewhat within the species depending upon the hardness and compactness of the substratum into which the specimen is boring. MacGinitie (1935) has given an excellent account of the boring of

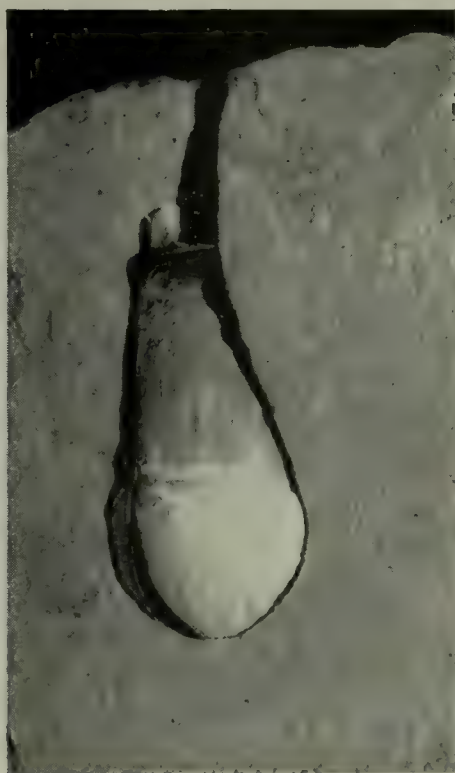


Plate 5. *Penitella penita* Conrad. A typical snug burrow of a *Penitella* boring in soft shale showing the depth to which this group usually bores. White's Point, San Pedro, California (about  $1\frac{1}{2}x$ ).

*Zirfaea gabbi* Tryon (= *Zirfaea pilsbryi* Lowe) and our observations on *Zirfaea crispata* Linné agree with his. Active specimens of this species, of *Barnea truncata* Say, and of *Martesia striata* Linné, which were observed in the laboratory, all followed the same general pattern. The foot was first attached to the anterior end of the burrow, the contraction of the anterior portion of the anterior adductor muscle and the ventral adductor muscle closed the valves anteriorly as much as possible, and the shell was brought as far forward in the burrow as possible. Then the forcible contraction of the posterior adductor muscle and the posterior portion of the anterior adductor muscle, by opening the valves ventrally and closing them posteriorly, brought the recurved imbrications of the beaks forcibly against the sides of the burrow. The insertion of the anterior adductor muscle on the umbonal reflection in an external position, allows the two sets of muscles to act in opposition to each other and produce a rocking and heaving motion of the valves with the umbos acting as a center.

Mechanically the shell is only capable of boring into a substratum that is as soft as the shell itself or softer. As the shells are composed of aragonite it is possible for them to bore into soft limestone without difficulty. When they are boring into a harder rock such as gneiss, there must be some elements in the rock which are softer than the shell itself or else the rock must be of a friable nature. In such cases the imbrications of the shell can work out the softer portions of the rock, such as the mica, and the harder particles of quartz, feldspar and garnets then fall out. Many of these harder particles apparently are caught in the mucus around the foot, on the thickened frontal margin of the mantle, and many have been observed impressed in the cephalic hood of *Zirfaea*. Particles are also caught between the rows of imbrications on the anterior portion of the valves and these may be in sufficient quantity to cover the worn imbrications. The result is that in species such as *Pholas dactylus* Linné the stone in many cases is worn away with particles of the same hardness.

While watching *Barnea truncata* Say and *Zirfaea crispata* Linné in an aquarium, it was noticed that they are capable of producing a strong and sizeable stream of water just ventral to the foot. This jet is forced out of the mantle cavity, the mantle edge being held close to the foot except for a small area just ventral to the foot. The stream is directed forward and probably is used to flush out the anterior end of the burrow.

Some species, such as *Zirfaea pilsbryi* Lowe (MacGinitie 1935) and *Cyrtopleura costata* Linné, excavate deep, rather roomy burrows and are capable of moving up and down in them at will. During high tide when they are feeding, the siphons may be seen extending a considerable distance out of the opening. Other species such as *Penitella penita* Conrad, as shown in the accompanying plate, excavate a very snug burrow in which movement is limited. This seems to be true of most boring into a hard substratum. The length of the burrow varies greatly with the different species. Some make burrows which are just about equal to the length of the shell, as is the case with *Martesia striata* Linné, while others may be several times the length of the shell. The type of burrow, however, is quite consistent for each species.

Specimens of *Barnea truncata* Say, *Zirfaea crispata* Linné and *Martesia striata* Linné when removed from their burrows are completely incapable of re-burying themselves. If, however, a shallow depression is made in the substratum just sufficient for the animal to attach its foot and bring the anterior edges of the shell into play, it will readily excavate a new burrow.

Little is known as to just how the young, particularly of the rock-boring forms, get started. One of the quaint early theories was that the parent could produce an acid in the tips of the siphons and with this make holes in the rock for the reception of the young. From observations made on *Zirfaea crispata* Linné it would appear that the young probably attach themselves by a single byssus thread in the protection of a minute crevice while metamorphosis takes place and the shell changes into a boring tool.

#### NOTES ON THE ANATOMY AND PHYSIOLOGY

The shell is the most unique anatomical feature of the Pholadidae, as no other family among the Pelecypoda has developed accessory plates. In addition, only the Teredinidae share with the Pholadidae the apophyses and the externally placed anterior adductor muscles. While no over-all study of the anatomy of the Pholadidae has been made, the gross morphology of several species has been reported upon and the detailed anatomy of a few is known. The first work was that of Poli (1791) in which he illustrated the anatomy of *Pholas dactylus* Linné, including detailed drawings of the gills, the circulatory and digestive systems. Fischer (1858–1860) described the general anatomy of several widely separated species including *Pholadidea melanura* Sowerby, *Parapholas acuminata* Sowerby and *Jouannetia globosa* Sowerby. Egger (1887) described in great detail the anatomy and histology of *Jouannetia cumingii* Sowerby. In all cases there are no real basic differences in the soft anatomy between these forms and other bivalves. Striking, though not basic differences, include the elongate gills of the pholads which extend into the incurrent siphon and the large triangular to strap-shaped labial palps. Observations on *Nettastomella rostrata* Valenciennes show that in this species the outer demibranchs of the gills are somewhat reduced, and that the labial palps are very small compared with those found in *Zirfaea* and in other genera. In *Xylophaga* only one demibranch remains and this is considered by Ridewood (1903) to be the inner one while Purchon (1941) believes that it is the outer one. Purchon also points out that the labial palps of *Xylophaga* are small and spindle-shaped, with a greatly reduced sorting mechanism. This is a condition that would be expected in wood-boring forms usually found living in floating wood, where most of the material brought in by the siphons is usually more or less uniform in size. In the mud and rock-boring forms, however, the ciliary sorting mechanism is highly developed.

The structure and function of the gills, ciliary mechanism, food tracts and method of feeding of *Zirfaea crispata* Linné were first described by Alder and Hancock (1851). Kellogg (1915) has given an excellent account of the ciliary mechanism in several groups including *Barnea*, *Zirfaea* and *Penitella*. Basically the ciliary mechanism in the species he examined was similar to that in other bivalves; however, several interesting differences were noted. Among these was the development of a covered food groove in *Zirfaea* to insure the delivery to the palps of the food collected on the gills. Of particular interest is his description of the "collecting membrane" found in *Barnea* [= *Cyrtopleura*] *costata* Linné. This membrane, extending from the posterior portion of the visceral mass, collects the excess silt and deposits it in a ball well out in the incurrent siphon whence it is expelled by a sudden contraction of the posterior adductor muscle. This apparently allows feeding at all times even in the very muddy water where this species often lives.

The crystalline style in all species examined was unusually large and, in the callum-

building forms, after the foot has atrophied, the style can be seen in the style sac protruding slightly from the anterior end of the visceral mass. Graham (1949) made a comparative study of numerous molluscan stomachs, including several species of pholads and showed their resemblance to the general type.

DuBois (1892) worked on the anatomy and physiology of *Pholas dactylus* Linné, but restricted his studies almost entirely to the siphons, and Purchon (1941) has dealt in detail with the biology and relationships of *Xylophaga*.

The callum-building pholads present two unique and rather interesting phenomena. In most species the animal appears to be able to store a considerable amount of calcium in its system, so that when the time comes the callum is laid down very rapidly. Among the thousands of specimens examined very few were found with the callum partially built. This undoubtedly is one of the reasons why the young stages of callum-building forms have so often been described in separate genera. Early workers, finding adult specimens (ones with a completed callum) which varied greatly in size, believed that the callum could be reabsorbed, that the animal could continue growth and then produce a second or even a third callum at a later date. This, however, is no longer considered the case, as in all of the callum-building forms the foot is absorbed once the callum is completed and boring has ceased. The muscles which work the valves during boring operations do not atrophy as might be expected, because a slight movement of the valves is still possible, and this movement is important for the circulation of water within the burrow.

The luminous properties of *Pholas dactylus* Linné have intrigued naturalists since early Greek times. In his writings Pliny speaks of the luminous fluid as being so abundant that the hands and mouths of those who ate them shone. An excellent summary of the experimental work on the bioluminescence of this species is given by Harvey (1952, pp. 255-267). Tomlin (1920) reports that specimens of *Xylophaga praestans* Smith were luminescent at night, but Purchon did not report this for *X. dorsalis* Turton. So far as is known no other species of Pholadidae is luminescent, with the possible exception of *Barnea candida* Linné which, according to Okada (1927), has a weak momentary luminescence when opened. However, the two species most closely related to *P. dactylus* Linné have not been investigated in this respect. The Western Atlantic form, *P. campechiensis* Gmelin, occurs mainly below low tide line and is almost unknown except as dead beach specimens. *Pholas chilensis* Molina of the Eastern Pacific is more common and should be investigated for this property. Living specimens of *Zirfaea crispata* Linné and *Barnea truncata* Say which we observed both in the laboratory and in the field showed no luminous properties.

All species of the Pholadidae, so far as known, live under strictly marine or only slightly brackish water conditions, with the possible exception of *Martesia rivicola* Sowerby, an Indo-Pacific species, which is recorded as occurring in floating wood in fresh water. Some species, however, appear to be able to withstand dilutions of sea water down to 50% for short periods of time. This would certainly indicate that, though these species are strictly marine, they have the ability to adjust themselves to the hazards of their intertidal habitat. Unlike *Venus*, *Mytilus* and others, they are unable to retract completely within their shells and so shut out the environment when conditions are adverse. A heavy rainfall at low tide could quickly fill the burrows of *Zirfaea* and *Barnea* with

nearly fresh water and consequently the ability to adjust to such changes probably has some survival value.

*Zirfaea crispata* Linné appears to be able to withstand a considerable range of temperature. Specimens placed in a jar of sea water and exposed to freezing temperatures became inactive when slush-ice was formed. On thawing, however, the animals again became active. In the summer they can tolerate water temperatures at least as high as 75° F.

### SHELL MORPHOLOGY

The pholad shell is complicated and highly specialized. Besides the two valves common to all pelecypods, some members of the Pholadidae may have as many as four accessory plates and all members have at least one. In some (the Pholadinae and Xylophaginae) there is no basic change from the young to the adult shell, while in others (the Martesiiinae) there are two distinct stages in shell growth. The young shell is beaked and widely gaping anteriorly, while in the adult the anterior gape is closed by a calcareous deposit,

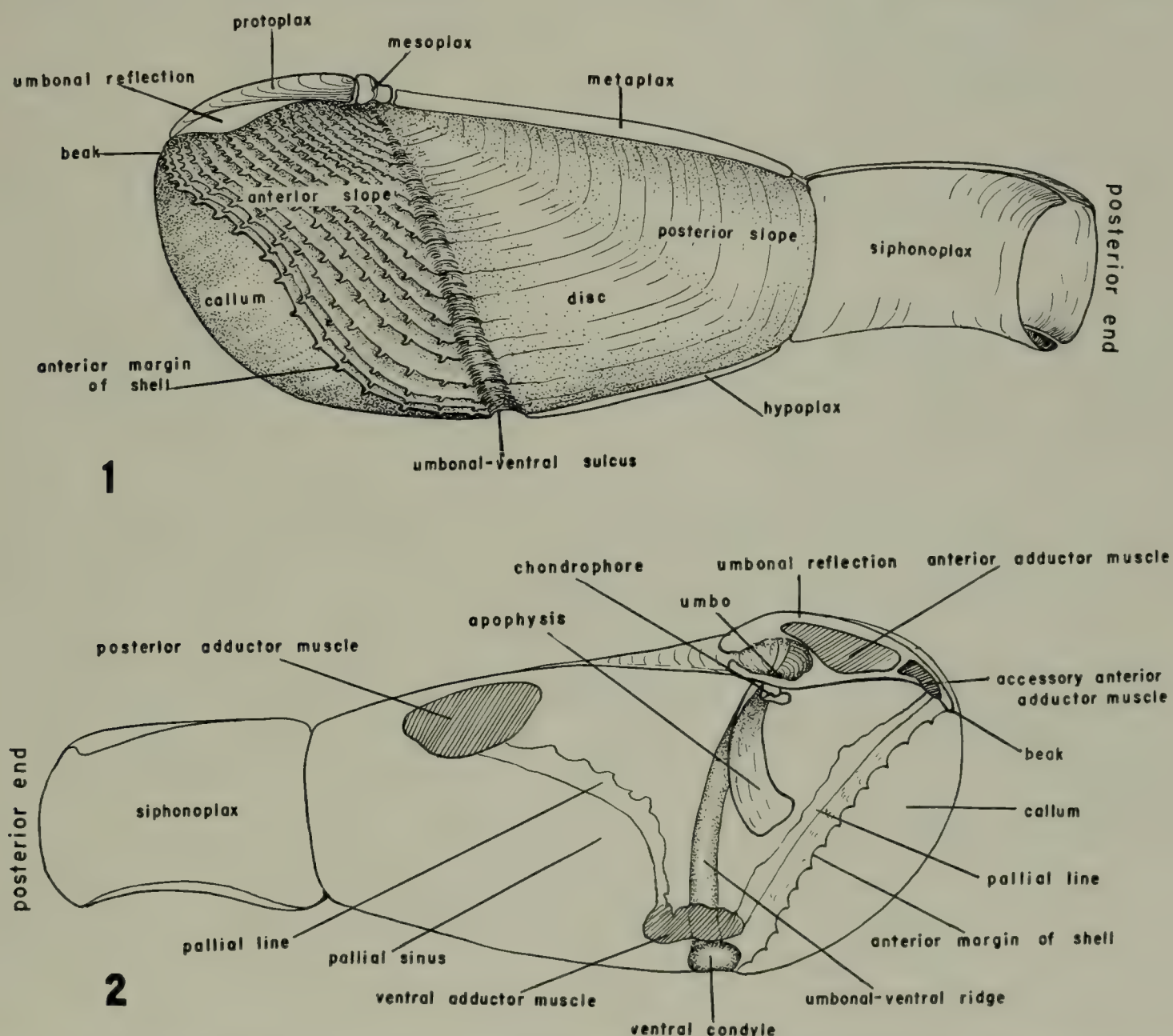


Plate 6. Diagrammatic, composite drawing of a pholad shell. Fig. 1. External view of the valve to show the approximate relative positions of the various accessory plates and the parts of the valve proper. Fig. 2. Internal view of the valve to show the general arrangement of the muscle scars, the placement of the apophysis and other parts.

the callum. The young stage which has been termed the "working or *Zirfaea* stage" by Lloyd (1897) continues as long as the animal is actively boring. During this stage the shells of several of the genera closely resemble those of *Zirfaea*; they are beaked anteriorly, rounded posteriorly and the mesoplax, the only accessory plate present at that stage, is a simple transverse plate located across the umbos and beneath the posterior portion of the anterior adductor muscle. The anterior adductor muscle is protected at this stage by a chitinous covering, sometimes referred to as the cephalic hood, a term more commonly used in the Teredinidae. When the excavation is completed and the animal ceases growing, the pedal gape is closed by a callum, the mesoplax is completed and the metaplax, hypoplax, and siphonoplax, if present, are developed. This stage, Lloyd (1897) has called the "resting stage." When the callum develops, the foot atrophies and the pedal gape of the mantle closes except for a minute anterior pore. Finally the completed halves of the callum are joined by a chitinous band, with only a minute anterior pore remaining open.

Most of the Pholadidae have apophyses, large shelly projections which extend from beneath the umbos and serve as the attachment area for the large foot muscles and as a support for the visceral mass. In all of the pholads the dorsal margins of valves are reflected anteriorly, so that the anterior adductor muscle is in an external position and works in opposition to the posterior adductor muscle.

Many of the following terms for the various parts of the shell and the accessory plates were first introduced by Fischer in 1858.

**PROTOPLAX.** The term protoplax is restricted to the simple, nearly flat dorsal plate which is anterior to the umbos and which rests on top of, but does not enclose, the anterior adductor muscle. It is essentially the same in young and adult shells and its axis is longitudinal. It may be in one piece or divided longitudinally into two equal parts. It may be chitinous or calcareous.

**MESOPLAX.** The mesoplax is a transverse plate, usually wider than long, which straddles the two valves on their dorsal margin. It protects the posterior portion of the anterior adductor muscle and always originates ventrally to the muscle. In the Pholadinae, the mesoplax is simple and essentially the same in the young as in the adult. In the Martesiinae, however, the mesoplax in the young is a simple, more or less semicircular plate situated mainly ventral to the posterior portion of the anterior adductor muscle. In the adult of these forms it grows dorsally and then anteriorly so as to enclose the posterior portion of the anterior adductor muscle. The mesoplax may be in one or two pieces and is always calcareous.

**METAPLAX.** The metaplax is a long, narrow plate which covers the gap between the two valves on the dorsal margin posterior to the umbos. It is usually calcareous and in most species is attached to the dorsal margins of the valves by a chitinous fold. The metaplax may be pointed, rounded or forked posteriorly.

**HYOPLAX.** The hypoplax is the long, narrow ventral plate covering the gape between the two valves on the ventral margin. It extends from the umbonal-ventral sulcus posteriorly, where it may be forked, rounded or pointed. It is usually entirely calcareous and is joined to the ventral margins of the valves by a chitinous fold.

**SIPHONOPLAX.** This term is applied to any structure which is secreted by the mantle on the posterior margin of the valves, probably for the protection of the siphons. The siphonoplax may be chitinous or calcareous, the two halves diverging or fused to form a tube. In *Jouannetia* the siphonoplax is developed on the right valve only.

**CALLUM.** This term refers to the closure of the pedal gape. It may be partial or complete, sculptured or irregularly marked. Generally the two halves of the callum do not quite meet and are joined by a chitinous fold, with only a minute anterior pore remaining open. In *Jouannetia* the callum of the left valve is greatly developed and overlaps that of the right valve. In *Nettastomella* the calcareous portion of the callum consists only of a narrow band extending along the anterior margin of the shell; the main portion of the callum is chitinous. In many species of Martesiinae the callum extends dorsally between the beaks and covers the anterior portion of the anterior adductor muscle.

**UMBONAL REFLECTION.** This term refers to the reflection of the dorsal margin of the valves anterior to and usually over the umbos. It may be closely appressed to the shell surface, raised well above the surface of the shell, with or without a posterior support, or the space below the reflection may be septate. The anterior adductor muscle scar usually covers most of the umbonal reflection.

**APOPHYSES.** These are large, styloid projections, one in each valve, extending from beneath the umbos to which the foot muscles are attached.

**CHONDROPHORE.** This is a modification of the hinge area to support the internal ligament. The chondrophore of the right valve is a small swelling with a central depression, while that of the left valve is a small shelf-like projection. The chondrophore is found in only certain groups of the pholads.

**SIPHONAL TUBE.** This term is applied to the tube produced in some members of the genus *Pholadidea*. It is composed of agglutinated particles produced as a result of boring activities. It differs from the 'chimney' of the *Parapholas* in that it is fused to the siphonoplax.

**CHIMNEY.** A tube formed of agglutinated particles produced as a result of boring activities. It fits over the posterior end of the shell and in some species extends anteriorly nearly to the mesoplax.

Other specialized terms can readily be understood from the accompanying diagram of a composite pholad shell on which all the various parts have been labeled. Only in the genus *Parapholas* are the three main areas of the shell as clearly marked as in the diagram. No one genus has all of the accessory parts indicated.

#### GENERAL REMARKS ON THE CLASSIFICATION

The family Pholadidae is a compact and easily recognized group. All of its genera possess three or more of several characters (such as accessory plates, callum, umbonal reflection, external position of the anterior adductor muscle, apophyses, ventral condyle, and chimney or siphonal tube) found in no other family of Pelecypods except the Tere-

dinidae. No pholad, however, has the elongate body and pallets of the Teredinidae and no teredo has accessory plates, callum or chimney.

The main difficulty faced by the early workers in the Pholadidae was the lack of material in which all the accessory plates were present. The basic shell in many of the species is very similar and when the accessory plates are lacking it is easy to misidentify them. Inadequately understood life histories resulted in the creation of new genera for the young stages of callum-building forms. In addition, the species are exceedingly variable. Therefore it is little wonder the early workers, having the extreme forms of a species with none of the intermediate ones, described them as different species. It is not unusual in this family to have adult specimens of a given species ranging from 3 mm. to 45 mm. in length, and the ratio of length to height is nearly as variable. This range of size and shape is a result of the boring habit of this group. The type of substratum in which the animals bore and the amount of crowding are largely responsible for the variation. Species which normally bore into wood become misshapen, small and thick-shelled when they work in harder materials. Overcrowding produces stenomorphs or greatly stunted forms which assume all of the adult characters though they are perhaps only 1/10 normal size. Conversely, species such as *Penitella conradi* Valenciennes [= *P. parva* Tryon], which normally bore into *Halotis* or other shells, are equally variable. When they live in softer material, such as heavy clay, the shell is much larger than normal and is far more perfectly formed. Consequently in this study an attempt has been made to obtain large series of preserved material from as many localities as possible in order to have a good picture of the range of size and shape of the species and the various types of malformations that normally occur.

On the death of the animal the accessory plates may become detached and isolated and these on occasion have been described, usually as species of simple gastropods of the type of *Scutum*, *Acmæa* or *Patella*. Mörch (1876) has pointed out that the dorsal plate of *Pholas* (*Monothyra*) *orientalis* Gmelin was described in 1779 by J. E. J. Walch as *Scutum dacicum* and in 1874 G. and H. Nevill again described it as *Scutum ? abnormis*. We have not seen the type specimen of *Scutum abnormis* but from the illustration there is no doubt as to its identity with the oriental species. The apophysis of *Cyrtopleura costata* Linné was described by Conrad as *Capulus shreevei* and it is very possible that *Patella acinaces* Lea 1846 is the dorsal plate of *Barnea truncata* Say. Undoubtedly there are other cases of such misidentifications which will eventually be clarified; some may possibly have been described as plates of barnacles. Isolated accessory plates occurring in fossil beds could prove a real problem to paleontologists.

Though the Pholadidae are known from the Pennsylvanian, the fossil record is meager and scattered and, of course, none of the soft parts have been preserved. On the basis of the present record it is impossible to say whether the Pholadidae and the Teredinidae stemmed from a single ancestor or whether the pholads gave rise to the teredos or vice versa. There is no question that the two families are closely related and that they either stemmed from a common ancestor or that one gave rise to the other. There are four distinct subfamilies in the Pholadidae all of which have accessory plates and an externally placed anterior adductor muscle. Of these four subfamilies, two have apophyses and two lack them. In each group there are callum and non-callum producing genera as shown in the following table.

<i>Subfamilies</i>	<i>Apophyses</i>	<i>Callum</i>	<i>Accessory Plates</i>
Pholadinae	X		X
Martesiinae	X	X	X
Xylophaginae			X
Jouannetiinae		X	X

### Family PHOLADIDAE

Shells with a narrow, slit-like to nearly circular pedal gape, which may or may not be closed by a callum in the adult stage. Anterior portion of the valves imbricate or denticulate and often ribbed. This portion is often separated from the posterior portion by an umbonal-ventral sulcus. Hinge teeth usually lacking, a small chondrophore present in some forms, ligament if present, internal. Anterior dorsal margin of the valves reflected, forming the attachment area for the externally placed anterior adductor muscle. The fused mantle edges in many forms are thickened and muscular. The ventral adductor muscle, present in some forms, is a thickened muscular portion of the ventral margin of the mantle. Anterior adductor muscle protected in the young stage by a chitinous covering often referred to as the cephalic hood. In the adult stage of most forms it is covered by accessory plates or by a dorsal extension of the callum. The total number of accessory plates in any one species may vary from one in *Barnea* and *Zirfaea* to four in *Martesia* and *Parapholas*. These last two forms have a mesoplax, metaplax, hypoplax and callum. A chimney is produced by *Parapholas* and *Xylophaga*. Apophyses are present in the Pholadinae and Martesiinae, but absent in the Jouannetiinae and Xylophaginae. For the distribution of the accessory plates in the various genera see the following table. Pallial sinus usually deeply inset. Siphons united, capable of considerable extension, smooth or papillose and often enclosed in a chitinous sheath. Siphonal aperture usually surrounded by cirri. Gills with two demibranchs, except in the Xylophaginae where there is only one, the outer one according to Purchon (1941). In many groups the gills are extended into the siphons. Foot well developed, usually truncate and adapted for suction. The foot in all of the Martesiinae and Jouannetiinae atrophy in the adult stage.

The following arrangement of the genera within the family is an attempt to group similar forms from those that are the simplest structurally to those that are the most complex. It is not intended to show any actual or supposed evolutionary sequence. The entire family is rather old geologically as shown on the following table, which gives the range in time, so far as is known, of the genera considered in this paper. However, it is often impossible to place fossil pholads in their proper genus owing to the fact that they may be only internal casts, that they lack the accessory plates, or that they are young forms. As represented today the family is composed of numerous well marked genera, each genus containing few species and seldom are species transitional between any two genera. This condition is paralleled by other groups in the Mollusca, where families, which are old geologically speaking, have become differentiated generically but now show little breakdown on the specific and subspecific levels.

### Subfamily PHOLADINAE

Shell not closed anteriorly by a callum in the adult stage. Number of accessory plates variable but hypoplax and siphonoplax always lacking. Apophyses present. Valves not divided into two regions by an umbonal-ventral sulcus, except in the genus *Zirfaea* where



the genus *Jouannetia* the callum is entirely calcareous and greatly produced. Apophyses lacking, the foot muscles being inserted in the normal position. Accessory plates variable; a rudimentary mesoplax is present in some species. The siphonoplax heavy, calcareous and in *Jouannetia* present only on the right valve. Anterior adductor muscle covered by the dorsal extension of the callum. Shells divided into two distinct areas by the umbonal-ventral sulcus. Foot well developed in the young stage but atrophied in the adult. Animal capable of complete retraction within the shell.

### Subfamily XYLOPHAGINAE

Shell beaked and gaping anteriorly throughout life. The beaks are truncated at nearly right angles, giving the shell a teredo-like appearance. Valves rounded and closed posteriorly, the animal capable of complete retraction within the shell. Anterior portion sculptured with numerous rows of finely denticulated ridges as in the Teredinidae. Posterior portion sculptured only by growth lines, and separated from the anterior portion by the umbonal-ventral sulcus. Accessory plates consisting only of a small divided mesoplax. Callum and apophyses absent. Umbonal-ventral ridge pronounced and usually with a ventral condyle. Umbonal reflection narrow, simple and closely appressed. Posterior adductor muscle scar large, generally oval in outline and placed high on the posterior slope. Foot muscle inserted in the normal position. Foot not atrophying in the adult.

### Distribution of accessory parts in the various genera of the Pholadidae

	Apophysis	Protoplax	Mesoplax	Metaplax	Hypoplax	Siphonoplax	Callum	Chimney
PHOLADINAE								
<i>Barnea</i>	X	X						
<i>Cyrtopleura</i>	X	X	X					
<i>Pholas</i>	X	X	X	X				
<i>Talona</i>	X		X					
<i>Zirfaea</i>	X		X					
MARTESIINAE								
<i>Chaceia</i>	X		X				X	
<i>Penitella</i>	X		X			X *	X	
<i>Pholadidea</i>	X		X			X	X	
<i>Parapholas</i>	X		X	X	X		X	X
<i>Diplothyra</i>	X		X	X	X		X	
<i>Martesia</i>	X		X	X	X		X	
JOUANNETIINAE								
<i>Jouannetia</i>			X *			X	X	
<i>Nettastomella</i>						X	X	
XYLOPHAGINAE								
<i>Xylophaga</i>			X					X

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\* Present in some but not all species in the genus.

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### Subfamily PHOLADINAE

#### Genus *Barnea* Risso

Shells white, more or less elliptical in outline, and beaked or rounded anteriorly. Accessory plate consisting of a simple, calcareous, lanceolate protoplax. Umbonal reflections simple, closely appressed to or raised slightly above the surface of the umbos, but free anterior to the umbos. Space below the umbonal reflections not septate. Pedal gape variable, ranging from a narrow slit to a broad oval. Sculpture consisting of concentric ridges and radial ribs which may cover the entire shell or may be reduced on the posterior slope.

The genus *Barnea* Risso is known from the temperate and tropical seas throughout the world.

Genotype, *Barnea spinosa* Risso (= *Pholas candida* Linné), monotypic.

There are two subgenera in the Genus *Barnea* and they may be differentiated as follows:

Shells rounded anteriorly	<i>Barnea</i> s.s.
Shells beaked anteriorly	<i>Anchomasa</i>

#### Subgenus *Barnea* Risso

*Barnea* 'Leach' Risso 1826, Histoire Naturelle de l'Europe Méridionale 4, p. 376 (genotype, *B. spinosa* Risso, monotypic).

*Barnia* Gray [sic] 1840, Synopsis Contents British Museum ed. 42, p. 150 [nomen nudum]; Gray 1842, Synopsis Contents British Museum, ed. 44, p. 76 [defined but no species listed].

*Barnia* Leach [sic] 1852, Synopsis of the Mollusca of Great Britain, London, p. 254 (genotype, *Barnea candida* Linné, monotypic).

*Holopholas* Fischer 1887, Manuel de Conchyliologie, Paris, p. 1133 (genotype, *Barnea candida* Linné, [here designated]).

Shells white, rounded at both ends, having a slit-like pedal gape and only a slight posterior gape. Umbonal reflections simple and closely applied to the surface of the umbos.

No species of this subgenus is known from the Western Atlantic or the Eastern Pacific. However, a description of the subgenus with a description and figures of *Barnea candida* Linné are included for the sake of comparison. Other species in this subgenus are found in West Africa and the Indo-Pacific.

#### *Barnea* (*Barnea*) *candida* Linné

Plates 7-8

*Pholas candida* Linné 1758, Systema Naturae, edition 10, p. 669; Hanley 1855, Ipsa Linnaei Conchyliia, p. 25.

*Pholas papyraceus* Spengler 1792, Skrivter Naturhistorie Selskabet 2, pt. 1, p. 92; *non papyracea* 'Solander' Turton 1822.

*Barnea spinosa* Risso 1826, Histoire Naturelle de l'Europe Méridionale 4, p. 376.

*Pholas dactyloides* Delle Chiaje 1829, Memoire Animali senza Vertebrae Regno Napoli 4, p. 206, pl. 65, figs. 9-12; *non* Lamarck 1818.

*Barnia* [sic] *candida* Linné, Gray 1851, Annals and Magazine Natural History (2) **8**, p. 382.

*Barnea candida* Linné, Bucquoy, Dautzenberg and Dollfus 1896, Mollusques Marins du Roussillon **2**, p. 615, pl. 88, figs. 1-7.

*Pholas candida* var. *subovata* Jeffreys 1865, British Conchology **3**, p. 108.

*Pholas cylindrica* J. Sowerby 1818, Mineral Conchology of Great Britain **2**, p. 223, pl. 198 (Crag).

*Pholas candida subovata cylindracea* Marshall 1914, Journal of Conchology **14**, no. 7, p. 207 (Torre Abbey, Torquay, England).

*Barnea candida cylindrica* 'Marshall' Lamy 1925, Journal de Conchyliologie **69**, p. 40 [error for *cylindracea* Marshall].

*Pholas costulata* Goodall 1890, Transactions Norfolk and Norwich Naturalists Society **5**, pt. 1, p. 79, text fig. (Hill Head near Gosport, England) [We have not seen this publication]; Walsingham 1916, Proceedings Malacological Society London **12**, p. 61, text figure.

**Distinctive characters.** Shell usually 3 inches or less in length, rounded anteriorly, with the sculpture extending over the entire shell and with a single dorsal plate, a protoplax.

**Description.** Shell subelliptical in outline, reaching about 68 mm. (about  $2\frac{3}{4}$  inches) in length and 25 mm. (about 1 inch) in height, thin, rounded anteriorly, tapering posteriorly and gaping slightly at both ends. Color a dull chalky white. Umbos prominent and located near the anterior  $\frac{1}{4}$  of the shell. Umbonal reflections closely appressed over the umbo but free anterior to the umbo. Sculpture consisting of concentric ridges and radial ribs. Concentric ridges very strong on the anterior slope, becoming weaker over the disc and on the posterior slope. Radial ribs rather weak, being expressed mainly by radial arrangement of the rows of imbrications which are produced where the concentric ridges and radial ribs cross. Imbrications particularly strong on the anterior slope but clearly visible, though weak, the entire length of the shell. Sculpture below the umbonal reflection consisting of fine growth lines. Interior of the shell white and glazed. Surface sculpture visible on the inner surface of the shell as faint furrows and pits. Pallial sinus extending inward to about  $\frac{1}{2}$  the distance to the umbo. Muscle scars faint. Apophysis small, short, slightly flattened and curved. Protoplax elongate oval, broadly arched, and with a central groove extending its entire length. Posterior end of the protoplax sharply

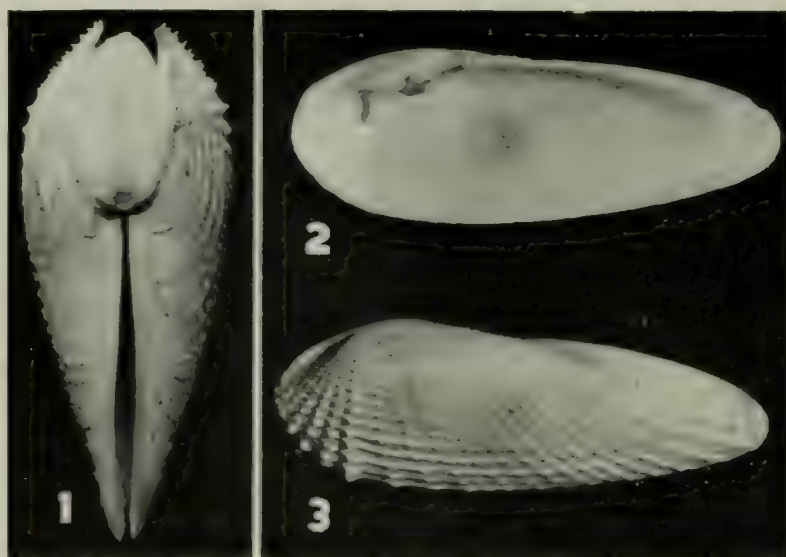


Plate 7. *Barnea candida* Linné. Figs. 1-3. Bréhec, Côtes du Nord, France (all natural size). Fig. 1. Dorsal view with protoplax in normal position. Fig. 2. Internal view showing apophysis, muscle scars and pallial sinus. Fig. 3. External view of valve showing umbonal reflection which is free anterior to the umbos and closely appressed over the umbos.

bent downward, nucleus posterior and concentric growth lines faint. Periostracum thin, straw-yellow and deciduous.

Siphons united, about equal in size and may be extended 4 to 5 times the length of the shell. They are pale brown in color and minutely papillose. The anterior portion of the siphons with a darker brown periostracal sheath which is joined to and extends over the posterior portion of the shell. Siphons tipped with a narrow band of red-brown. Incurrent siphon with 10 to 12 large and several small cirri surrounding the opening. These cirri continue internally as ridges which extend well down in the siphons. The red-brown coloring also extends internally largely between the ridges. Excurrent siphon lacking cirri and with only a very narrow color band internally. Foot white, oblong-lanceolate in outline and truncate. Pedal gape long and narrow, mantle white. The above description was made from preserved animals.

length	height	ratio h:l	
68.2 mm.	25.0 mm.	2.7	Cintra Bay, Rio de Oro, Africa
56.0	19.4	2.8	Ostende, Belgium
52.0	19.0	2.7	Castle Rocks, St. Andrews, Fife, Scotland

*Types.* According to Hanley (1855, *Ipsa Linnaei Conchyliæ*, p. 25) Linné's specimens of *Pholas candida* are still in the Linnean collection. The locality given by Linné was Europe and America, his reference was to Lister 1678, *Historiæ Animalium Angliæ*, p. 193, pl. 5, fig. 39. The type locality is here restricted to the Tees River, Middlesbrough, England, the locality given by Lister.

The locations of type specimens of most of the species now considered synonyms of *Barnea candida* Linné are unknown.

*Remarks.* *Barnea candida* Linné, similar to all other species in this genus and family, is rather variable in size, proportions and condition of sculpturing depending upon the substratum in which it is boring. This undoubtedly has been responsible for the large number of synonyms noted above. This species is known to bore into a variety of substrata ranging from loose sand to rock.

Through the kindness of Professor C. M. Yonge and Dr. J. M. Dodd of the University of Glasgow, we have received preserved specimens from the Gatty Marine Laboratory, St. Andrews, Scotland. At this station *Barnea candida* Linné bore into mudstone, a form of shale which is quite plastic when wet. They live in the same area as *Zirfaea crispata* Linné, but at a higher tide level and their burrows generally are horizontal while those of *Zirfaea* are nearly always vertical.

Deshayes (1846, *Exploration Scientifique de l'Algerie, Histoire Naturelle des Mollusques*, Liv. 6, pl. 9) has figured beautifully the general morphology of the soft parts of this species, and Bucquoy, Dautzenberg and Dollfus give a very complete bibliography prior to 1896.

*Range.* From northern Norway south to the southern coast to France, the eastern Mediterranean, and on the African coast south to Cap Blanc, Sénégal (M. Nicklès, 1950).

*Specimens examined.* NORWAY: Malvik, Trondheim Fjord; Beian, Orlandet, Trondheim (both MCZ). SCOTLAND: Oban (MCZ; USNM). ENGLAND: Huntstonton

(USNM): Scarborough: Kent; Eastbourne, Sussex; Teignmouth; Cornwall (all MCZ); Poole (USNM). NETHERLANDS: Scheveningen (MCZ). BELGIUM: Nieuport (W. J. Eyerdam); Ostende (MCZ). FRANCE: Bréhec, Côtes du Nord; Nantes; Cette (all MCZ); Gulf of Gascogne (USNM). AFRICA: Cintra Bay, Rio de Oro (MCZ).

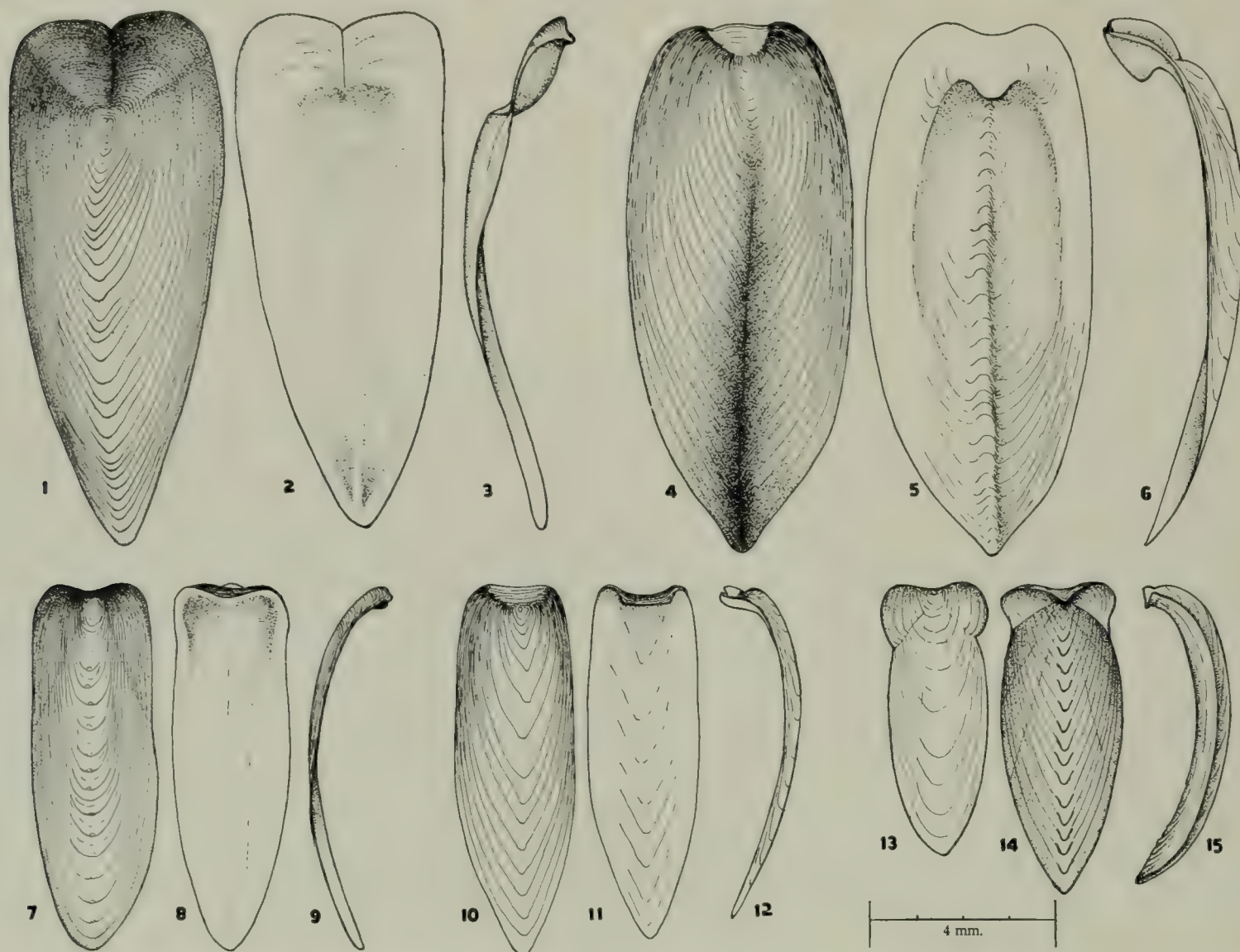


Plate 8. Protoplax of *Barnea*. Figs. 1-3. *Barnea subtruncata* Sowerby, Liddo Isle, Newport Bay, California. Fig. 1. Dorsal view showing the tapering sides, the concentric growth lines and the nucleus which is located well in from the posterior margin. Fig. 2. Ventral view. Fig. 3. Side view to show the curvature. Figs. 4-6. *Barnea candida* Linné, Bréhec, France, Fig. 4. Dorsal view showing the posterior nucleus and the distinct median groove. Fig. 5. Ventral view showing the groove expressed internally as a ridge. Fig. 6. Side view. Figs. 7-9. *Barnea truncata* Say, Third Cliff, Scituate, Massachusetts. Fig. 7. Dorsal view showing the nearly parallel sides, the concentric growth lines and the nucleus which is located close to the posterior margin. Fig. 8. Ventral view. Fig. 9. Side view. Figs. 10-12. *Barnea parva* Pennant, Plymouth, England. Fig. 10. Dorsal view showing the growth lines and the location of the nucleus. Fig. 11. Ventral view. Fig. 12. Side view. Figs. 13-15. *Barnea lamellosa* d'Orbigny, Puerto Militar, Bahía Blanca, Buenos Aires, Argentina. Fig. 13. Dorsal view showing the weak concentric growth lines, the posterior nucleus and the posterior lobes. Fig. 14. Ventral view showing the longitudinal ridge. Fig. 15. Side view showing the curvature and the upturned lateral margins.

### Subgenus *Anchomasa* Leach

*Anchomasa* Leach 1852, A Synopsis of the Mollusca of Great Britain, London, p. 253.

Shell beaked anteriorly, with a large oval pedal gape extending back at least as far as the umbo, rounded to truncate posteriorly with a moderate to large and variable posterior

gape. Umbonal reflection simple and usually closely applied to the surface of the umbo, free anteriorly.

Subgenotype, *Anchomasa pennantiana* Leach (= *Pholas parva* Pennant), monotypic.

### **Barnea (Anchomasa) parva Pennant**

#### **Plates 8-9**

*Pholas parva* Pennant 1777, British Zoology 4, p. 77, pl. 40, fig. 13 (English shores); *non parva* Sowerby 1834; *non parvus* Donovan 1800.

*Pholas crenulatus* 'Solander' Spengler 1792, Skrivter Naturhistorie Selskabet 2, pt. 1, p. 98.

*Pholas dactyloides* Lamarck 1818, Histoire Naturelle des Animaux Sans Vertèbres 5, p. 445 (British Seas).

*Pholas tuberculata* Turton 1822, Conchyliæ Insularum Britannicarum, p. 5, pl. 1, figs. 7-8 (Torbay, England).

*Pholas ligamentina* Deshayes 1839, Traité Élémentaire de Conchyliologie 1, pt. 2, p. 80, pl. 3, figs. 11-12 (Seas of Europe).

*Barnia* [sic] *parva* Pennant, Gray 1851, Annals and Magazine of Natural History (2) 8, p. 382.

*Anchomasa pennantiana* Leach 1852, Synopsis of the Mollusca of Great Britain, p. 253 (Kingsbridge Estuary and Sussex, England).

*Zirfaea callosa* 'Lamarck' Chenu 1862, Manuel de Conchyliologie 2, p. 6, figs. 24-25.

*Barnea* (*Anchomasa*) *parva* Pennant, Tryon 1862, Proceedings Academy Natural Sciences Philadelphia, p. 209.

*Barnea parva quadrangula* Jeffreys 1865, British Conchology 3, p. 110 (England).

*Holopholas* (*Anchomasa*) *parva* Pennant, Fischer 1886, Manuel de Conchyliologie, p. 1133.

*Pholas duboisii* Locard 1892, Les Coquilles Marines des Côtes de France, p. 246 (coast of France and English Channel).

*Pholas* (*Barnea*) *parva* var. *major* Pallary 1900, Journal de Conchyliologie 48, p. 413, fig. 19 (St. Thérèse, Oran [Algeria]).

**Distinctive characters.** Shell strongly beaked anteriorly, narrowly rounded posteriorly, solid, with a large rounded condyle and a lanceolate protoplax.

**Description.** Shell reaching 38 mm. (about  $1\frac{1}{2}$  inches) in length and about 16 mm. (about  $\frac{1}{2}$  inch) in height, rather strong in structure, beaked anteriorly, rounded posteriorly, gaping at both ends and with the sculpture disappearing on the posterior slope. Color a dull chalky white. Umbos prominent and located near the anterior third of the shell. Umbonal reflections narrow, rather thick and raised above the umbos. Sculpture consisting of radial ribs and concentric ridges. Concentric ridges strongly laminated anteriorly, becoming weak on the disc and disappearing on the posterior slope. Radial ribs closely set on the anterior slope, barely visible on the disc and lacking on the posterior slope. Imbrications are produced where the concentric ridges and radial ribs cross one another. In most specimens the radial arrangement of the imbrications is the only evidence of the ribs. Sculpture beneath the umbonal reflection consisting only of laminated

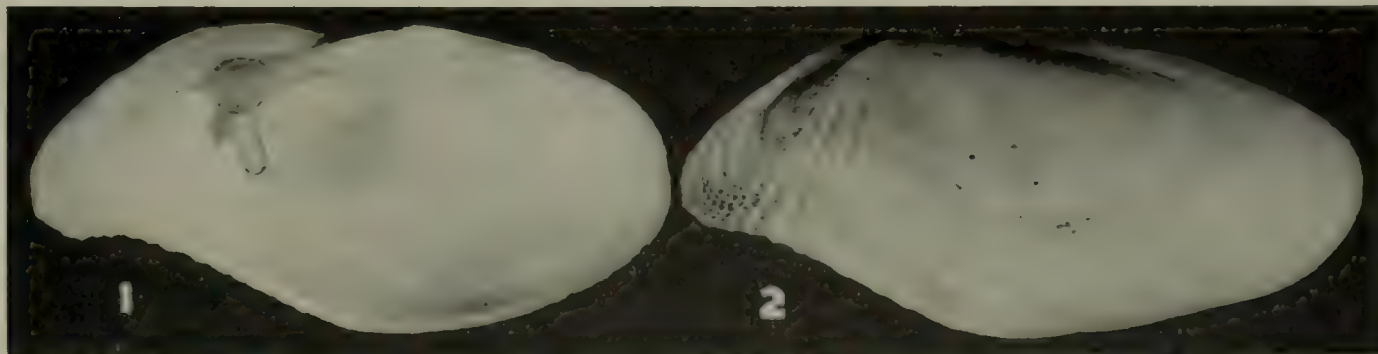


Plate 9. *Barnea parva* Pennant. Fig. 1. Nantes, France (2x). Showing the large knob-like condyle. Fig. 2. Tenby, Pembroke, Wales (2x).

ridges. Interior of shell white and glazed. Pallial sinus wide and deep, extending inwardly almost to the umbo. Pallial line and muscle scars barely visible on the specimens examined. Radial ribs visible internally on the anterior slope. Condyle knob-like, large and heavy and extending inward so that when the two valves are in juxtaposition they are quite widely separated along the dorsal margin. Apophysis narrow and thin. Proto-plax lanceolate. Periostracum thin, and straw-yellow in color.

Siphons united and may be extended 1 to 2 times the length of the shell. They are thickly covered with small papillae, fawn-brown in color and have a narrow whitish band surrounding the openings. Incurrent siphon nearly three times the diameter of the excurrent siphon and with three large and several small ridges extending well down within. Excurrent siphon smooth internally. Internal surface of both siphons white to pale yellow. Foot and mantle white to pale yellow. Foot large, nearly circular in outline and truncate. The above description of the soft parts is based on preserved specimens received through the kindness of Dr. F. S. Russell, Director of the Plymouth Laboratory, England.

length	height	ratio h:l	
38.0 mm.	16.0 mm.	2.4	Nantes, France
35.5	16.0	2.2	Tenby, Pembroke, Wales
25.5	13.5	1.8	Plymouth, England
24.0	12.0	2.0	Plymouth, England
22.5	12.0	1.8	Tenby, Pembroke, Wales

*Types.* The type of *Barnea parva* Pennant is probably in the British Museum. According to Sherborn 1940, the collections of Pennant were deposited in the British Museum in 1912. The type locality is Abergelli [Abergele] in Denbighshire, Wales. The locations of the type specimens of most of the species now considered synonyms of *Barnea parva* Pennant are unknown.

*Remarks.* *Barnea parva* Pennant is the type of the subgenus *Anchomasa* and for this reason we include a description of it here. It is a rather small and variable species with an unusually heavy shell for a *Barnea* of this size. It is characterized by its pronounced beak, its closely packed concentric ridges and radial ribs, its prominent dorsal condyles and the narrowly rounded posterior margin. *Barnea parva* Pennant most nearly approximates *Barnea lamellosa* d'Orbigny of Argentina. The posterior margins of both species are rounded and tapering and in both, the hinge area is somewhat knob-like. *Barnea parva* Pennant, however, has a much heavier, more solid shell, with close-set laminated ridges and a simple non-lobed proto-plax. From *Barnea truncata* Say which has also been found in the Eastern Atlantic on the African coast, *B. parva* Pennant is distinguished by its rounded posterior margin, more pronounced beaks, heavy shell, and more knob-like development of the hinge area.

*Barnea parva* Pennant is apparently a rather rare species with a somewhat restricted range. Forbes and Hanley 1853 state that while found with *Barnea candida*, *Pholas dactylus* and *Zirfaea crispata*, it is always far less abundant. It bores into soft sandstone, stiff clay and decaying waterlogged wood, the general shape and size of the specimen depending upon the hardness of the material into which it is boring. It is this variation that has, no doubt, been responsible for the large number of synonyms noted above. The

specimens which Pennant cites in his original description as coming from wood taken at Pensacola, Florida, were no doubt malformed specimens of *B. truncata*. When boring in such hard material they often look very much like *parva*, but never are as heavy in structure nor do they possess the large knob-like condyles.

Dr. M. V. Labour<sup>1</sup> states that this species is common in the rocks at Rum Bay, Plymouth, England and that they appear to breed in summer and early autumn. She reared the larvae to the first shell stage and described and figured them. Like most bivalves, the larval shell is very small, being only .08 mm. in length and extremely simple in structure. When .32 mm. in length, it begins to assume the adult form, developing an anterior portion which is imbricated and suitable for boring, and a posterior portion for the protection of the siphons.

*Range.* Southern British Isles south to Oran, Algeria (Pallary).

*Specimens examined.* WALES: Tenby, Pembroke (MCZ). ENGLAND: Tor Bay, Devon (Charleston Museum); Brighton, Sussex (W. J. Eyerdam); Plymouth (Plymouth Lab.). FRANCE: Nantes (MCZ). La Rochelle (USNM).

***Barnea (Anchomasa) lamellosa* d'Orbigny**  
Plates 8 and 10

*Pholas lamellosa* d'Orbigny 1846, Voyage Amérique Méridionale 5, pt. 3, Mollusques, p. 498, pl. 77, figs. 20-21 (shore of Patagonia to the south of Rio Negro).

*Barnea (Anchomasa) subtruncata* var. *lamellosa* d'Orbigny, Lamy 1925, Journal de Conchyliologie 69, p. 82.

*Barnea (Anchomasa) subtruncata lamellosa* d'Orbigny, Carcelles 1944, Revista Museo de la Plata (n.s.) Zoologia 3, p. 295, pl. 14, figs. 108-109; Carcelles 1950, Anales del Museo Nahuel Huapi 2, p. 82.

*Distinctive characters.* Shell white, beaked anteriorly, rounded posteriorly, with the umbonal reflections free for their entire length, with a large rounded condyle and a single dorsal plate, the protoplax, which is strongly keeled and eared posteriorly.

*Description.* Shell reaching about 43 mm. ( $1\frac{3}{4}$  inches) in length and about  $18\frac{1}{2}$  mm. (about  $\frac{3}{4}$  inch) in height, thin, frail, pointed anteriorly, rounded posteriorly, gaping at both ends, and with the sculpture disappearing on the posterior slope. Color a dull chalky-white. Umbos prominent, partially covered by the umbonal reflections and located near the anterior third of the shell. Umbonal reflection free for its entire length, the space

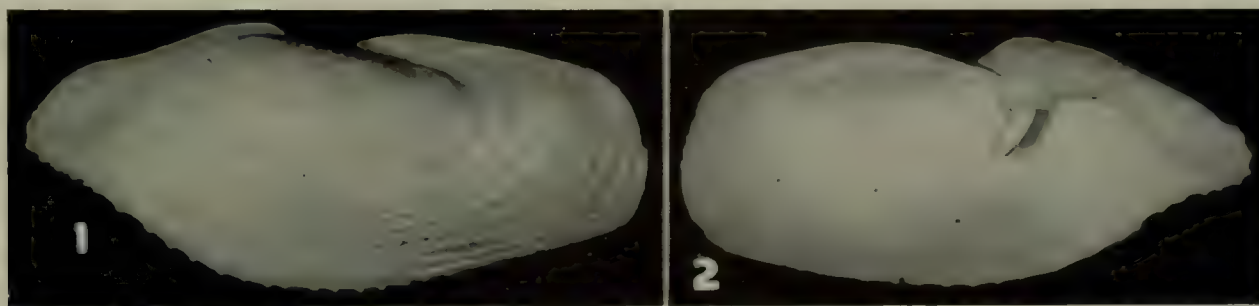


Plate 10. *Barnea lamellosa* d'Orbigny, Mar del Plata, Argentina (2x). Fig. 1. Showing the free umbonal reflection and high posterior slope. Fig. 2. Showing the muscle scars and apophysis.

<sup>1</sup> Labour, M.V. 1933, Journal of the Marine Biological Association of the United Kingdom 23, no. 1, pp. 132-135.

between it and the umbo being very small in young specimens and increasing slightly in older shells. Sculpture consisting of rather strong concentric ridges and moderate to rather weak radial ribs. Concentric ridges laminated anteriorly, becoming smoother and weaker posteriorly until they are nearly obsolete on the posterior slope. Radial ribs generally rather weak and in adult specimens usually completely lacking on the posterior slope. Imbrications are produced where the radial ribs and concentric ridges cross. The strength of these imbrications varies greatly depending on the age of the specimen and the strength of the ribs. On young specimens (up to 12 mm. in length) they may even be present on the posterior slope. In the rather small series available for study the radial arrangement of the imbrications was the only evidence of the existence of the radial ridges, there being no trace of them between the crests of the concentric ridges. Sculpture below the umbonal reflection composed of crowded laminated growth lines. Interior of shell white and glazed, with the concentric lines and ridges showing through the shell. Pallial sinus nearly as wide as the shell is high and extending inward nearly half the distance to the umbo. Apophyses narrow, flattened, and extending downward about  $\frac{1}{3}$  of the way to the ventral edge of the shell.

Protoplax lanceolate with a posterior nucleus and well marked growth lines, pointed anteriorly, broad and eared posteriorly, strongly keeled, and with a strong hook at the posterior end which fits over the prominent umbos. Pedal gape rounded anteriorly, pointed posteriorly and extending backward about one half the length of the shell. Periostracum very thin, straw-yellow and deciduous.

The siphons are united and may be extended 4 to 5 times the length of the shell. The covering of the siphonal tubes in preserved material is medium to dark-brown in color and papillose. There are 8 to 10 short stout papillae surrounding the end of the incurrent siphon. These papillae extend inside as marked white ridges almost the entire length of the incurrent siphon, the spaces between the ridges a dark red-brown. The excurrent siphon lacks papillae and is smooth within. The strongly muscular mantle collar surrounding the foot and forming the pedal gape is notched anteriorly at the ante-umbonal gape.

length	height	ratio h:l	
42 mm.	19 mm.	2.2	Mar del Plata, Argentina
38	15	2.5	Puerto Quequen, Buenos Aires, Argentina

*Types.* The holotype of *Barnea lamellosa* d'Orbigny is in the British Museum, according to Gray 1854, List of the Shells of South America in the Collection of the British Museum Collected and Described by M. Alcide d'Orbigny, p. 55. The type locality is the mouth of the Río Negro, Argentina.

*Remarks.* *Barnea lamellosa* d'Orbigny is close in its relationship to *B. truncata* Say. It differs, however, in being more rounded rather than truncate posteriorly, in having the umbonal reflection free for its entire length and in having the protoplax strongly keeled, more pointed anteriorly and eared posteriorly. *Barnea lamellosa* d'Orbigny also appears to be a much smaller species and to have much weaker sculpture with more closely set concentric ridges than *B. truncata* Say. See also remarks under *B. parva* Pennant.

Though specimens of *B. lamellosa* are exceedingly rare in museum collections in this country, it is probably not a rare species. It has a limited distribution and is further restricted by its specialized habitat of mud and peat areas. Through the kindness of A. Carcelles we have had specimens from several localities in Argentina for study. We agree

with Carcelles that this species is not the same as the one found in Peru, as has been stated by several authors. This species has a characteristic eared protoplax, a heavy condyle and a much more rounded posterior margin than *B. subtruncata* Sowerby, the Eastern Pacific species.

*Range.* From off Cabo Polonio, Uruguay south to Golfo Nuevo, Argentina.

*Specimens examined.* URUGUAY: Off Cabo Polonio (S. Lat.  $34^{\circ}42'$ ; W. Long.  $54^{\circ}10'$ ) (A. Carcelles). ARGENTINA: Mar del Plata; Bahía Blanca; Puerto Quequen; Canal la Manuelita; Puerto Belgrano; Bahía San Blas, all in the State of Buenos Aires; 5 miles south of Punta Medano, Río Negro; Puerto Madryn and Golfo Nuevo, Chubut (all A. Carcelles). Río Negro (USNM).

### ***Barnea (Anchomasa) truncata* Say**

Plates 8 and 11 to 13

*Pholas truncata* Say 1822, Journal Academy Natural Sciences Philadelphia **2**, p. 321 (southern coast of United States).

*Pholas (Cyrtopleura) truncata* Say, Tryon 1862, Proceedings Academy of Natural Sciences Philadelphia **14**, p. 202.

*Barnea truncata* Say, Dall 1898, Transactions Wagner Free Institute of Science, Philadelphia **3**, part 4, p. 816.

*Barnea (Cyrtopleura) truncata* Say, Lamy 1925, Journal de Conchyliologie **69**, p. 87.

*Distinctive characters.* Shell beaked anteriorly, truncate posteriorly, sculpture greatly reduced or entirely lacking on the posterior slope, and with a single dorsal plate, the protoplax.

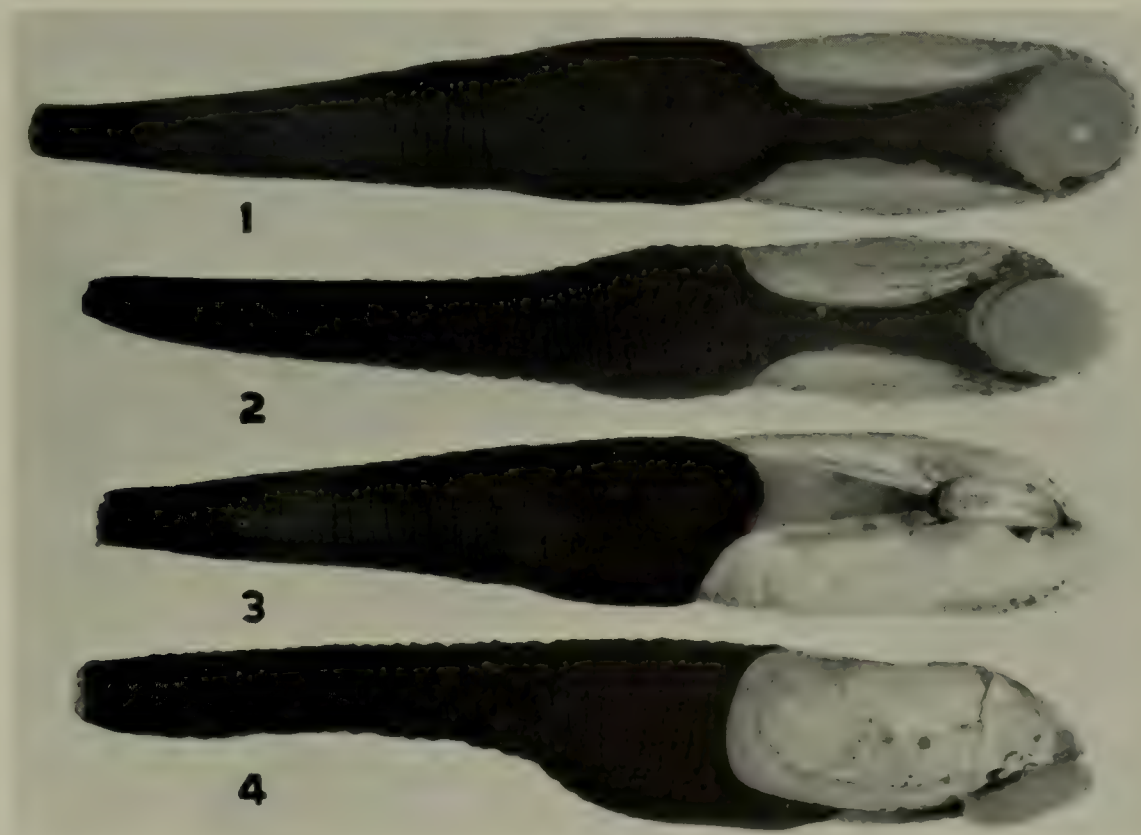


Plate 11. *Barnea truncata* Say. Woods Hole, Massachusetts (natural size). Living specimens photographed in test-tubes. Fig. 1. Ventral view of specimen in a more or less relaxed condition with the longitudinal muscles slightly contracted and showing the extent to which the valves can be separated. Fig. 2. With foot well extended and the longitudinal and circular muscles of the siphons moderately contracted. Fig. 3. Dorsal view showing the protoplax in place and the extent to which the valves can be separated dorsally. Fig. 4. Side view showing the extended foot and the circular muscles of the siphons contracted.

*Description.* Shell reaching 70 mm. (about  $2\frac{3}{4}$  inches) in length and 25 mm. (about 1 inch) in height, light in structure, beaked anteriorly, gaping at both ends and with the sculpture disappearing on the posterior slope. Color a dull chalky-white. Umbos prominent and located near the anterior third of the shell. Umbonal reflections rather closely appressed over the umbos but free anteriorly. Sculpture consisting of radial ribs and concentric ridges. The concentric ridges strong and laminated anteriorly, becoming gradually weaker posteriorly until they are nearly obsolete on the posterior slope. Radial ribs fairly strong on the anterior slope, diminishing in strength on the disc and completely lacking on the posterior slope. Imbrications are produced where the radial ribs and concentric ridges cross. In some specimens, the radial arrangement of these imbrications is the only evidence of the existence of the radial ribs. The degree of sculpturing below the umbonal reflection varies greatly, even among specimens from the same locality, ranging from very weak growth lines to sculpture almost as strong as that on the anterior slope. Interior of the shell white and glazed. Pallial sinus nearly as wide as the shell is high and extending within nearly half the distance to the umbo. Pallial line and muscle scars clearly indicated especially on older specimens. Apophyses long, narrow, curved and blade-like, occasionally broadening slightly at the free end. Protoplax broadly lanceolate, with a posterior nucleus and well marked growth lines. It is curved downward at its posterior extremity to fit over the umbo. Periostracum thin, straw-yellow to light-brown in color and deciduous.

Siphons united and enclosed in a tough, brown, papillose sheath, the incurrent siphon being a little larger than the excurrent. They may be extended 10 to 12 times the length of the shell, and, when fully extended, the periostracal covering is so stretched that they appear a light brownish-gray to white. However, on contraction they become a uniform dark brown their entire length. Incurrent siphon fringed with 8 to 10 short, stout, unbranched papillae. Between these papillae there are brown to mahogany-red markings which extend down inside the siphon. The excurrent siphon lacks the papillae but usually possesses the brown internal markings. The dark periostracal covering extends anteriorly between the valves on the ventral surface so that only the immediate area surrounding the foot is white. Foot white, oval in outline and truncate.

length	height	ratio h:l	
70.0 mm.	27.0 mm.	2.6	Duxbury, Massachusetts
66.5	26.5	2.5	Sarasota, Florida
62.0	29.5	2.1	Mattituck, Long Island, New York
59.0	25.0	2.4	Duxbury, Massachusetts
54.0	23.0	2.3	Cotype
47.0	21.5	2.2	Marion, Massachusetts
44.5	20.0	2.2	Newport, Rhode Island

*Types.* A probable cotype of *Pholas truncata* Say is in the Academy of Natural Sciences Philadelphia, no. 50775, a specimen received from Mrs. Say. Say's type locality was simply the southern coast of the United States. We here restrict the type locality to Charleston, South Carolina, a region from which Say received much material.

*Remarks.* *Barnea truncata* Say is very close in its relationship to *B. subtruncata* Sowerby from the Eastern Pacific. It is, however, generally a smaller, more fragile shell, with less inflated valves and shorter post-umbonal length. In addition, the protoplax is less tapering. In most of the above shell characters, however, there are intergrades, though in a

large series the two forms appear quite distinct. For additional remarks on relationship to the west coast form see under *B. subtruncata* Sowerby. See also remarks under *Barnea lamellosa* d'Orbigny.

Specimens of *Barnea truncata* Say are found in mud, clay and peat deposits along the coast from Maine to Brasil wherever strictly marine conditions exist. The distribution of this species north of Cape Cod is extremely local and specimens from Maine, the northern limit of its range, are exceedingly rare. The species again becomes rare on the southern end of its range. It would appear that in this area they are probably living in deeper water, and being deep borers the shells seldom get washed ashore. Harold W. Harry<sup>1</sup> reports that *Barnea truncata* was found commonly in the beach drift at Timbalier Island and Caminada, Louisiana. However, to our knowledge, no living specimens have been collected in the northern Gulf or in the West Indies.

Large specimens of *B. truncata* may bore holes nearly a foot or more in depth and though usually found inhabiting the intertidal region they occasionally may be found at considerable depths. Small specimens of this species were found in a piece of waterlogged wood tossed up on the beach at Cape Canaveral, Florida. These specimens were stunted and malformed, the wood being much harder than the material into which they normally bore. A similar malformed specimen in the collection of the Charleston Museum was labeled as boring in rock in Charleston Harbor. This was probably the hard marl or phosphate rock of that area, a substance much too hard for *B. truncata* to bore into successfully. The beaks of these specimens were greatly produced, the rows of imbrications exceedingly close together, and the posterior slope much reduced in size. Specimens from several localities on the west coast of Florida in the vicinity of Sarasota appear to be some-

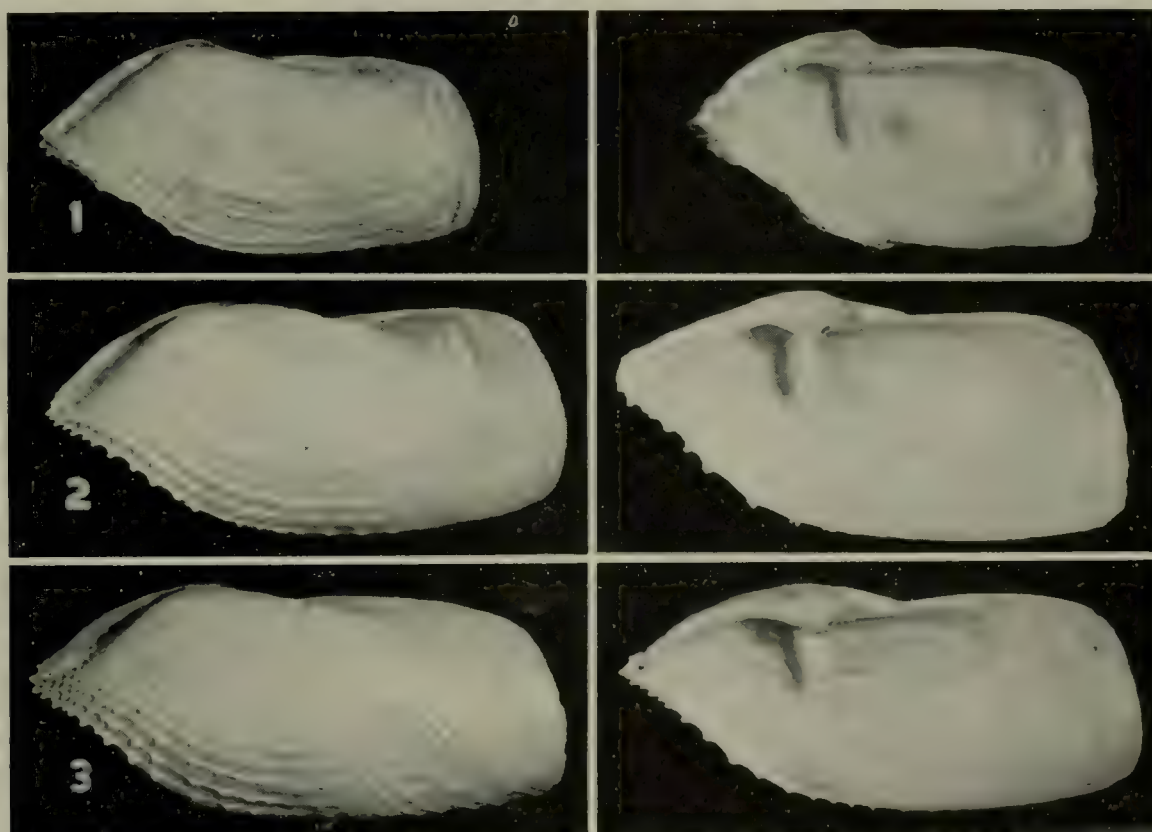


Plate 12. *Barnea truncata* Say. Figs. 1, 3. Newport, Rhode Island. Fig. 2. Duxbury, Massachusetts. Selected series to show variation in the length-height proportion (all natural size).

<sup>1</sup> Harold W. Harry 1942, Occasional Papers Marine Laboratory, Louisiana State University, Baton Rouge, Louisiana, no. 1, p. 3.

what longer in proportion to their height and to have the posterior margin more rounded than the typical form. This may be due to ideal conditions of the substrata and a good food supply so that the specimens grew more rapidly than usual.

Edward Sylvester Morse found that the animals when cooked were quite edible, but had a peculiar smoky taste.

Addison E. Verrill (1873), appears to have confused the soft parts of *Barnea truncata* and *Zirfaea crispata*, for he describes the siphons of *truncata* as "generally yellowish-white except at the very end, where they are blackish or brownish; the orifices and papillae are also variously marked with purplish brown or dark brown. The dark coloration at the end of the siphon tubes is doubtless for purposes of protection from predaceous fishes, crabs, etc." This description fits perfectly the siphons of *Z. crispata*, but the siphons of *B. truncata* are a uniform grayish-brown their entire length.

*Range.* WESTERN ATLANTIC: Maine (C. W. Johnson) south to the Gulf of Mexico, probably in restricted localities throughout the West Indies, and south to Sepetiba Bay, Rio de Janeiro, Brasil.

EASTERN ATLANTIC: From Bel Tir, Dakar, Sénégal south to Accra, Gold Coast.

*Specimens examined.* WESTERN ATLANTIC: MASSACHUSETTS: Salem (MCZ; USNM); Chelsea Beach (USNM); Scituate; Duxbury; Marion; Dennisport; West Harwich; Hyannis; Woods Hole (all MCZ); Lagoon Pond, Marthas Vineyard; Cuttyhunk Island (both G. Moore); New Bedford (ANSP). RHODE ISLAND: Newport; Warren (both

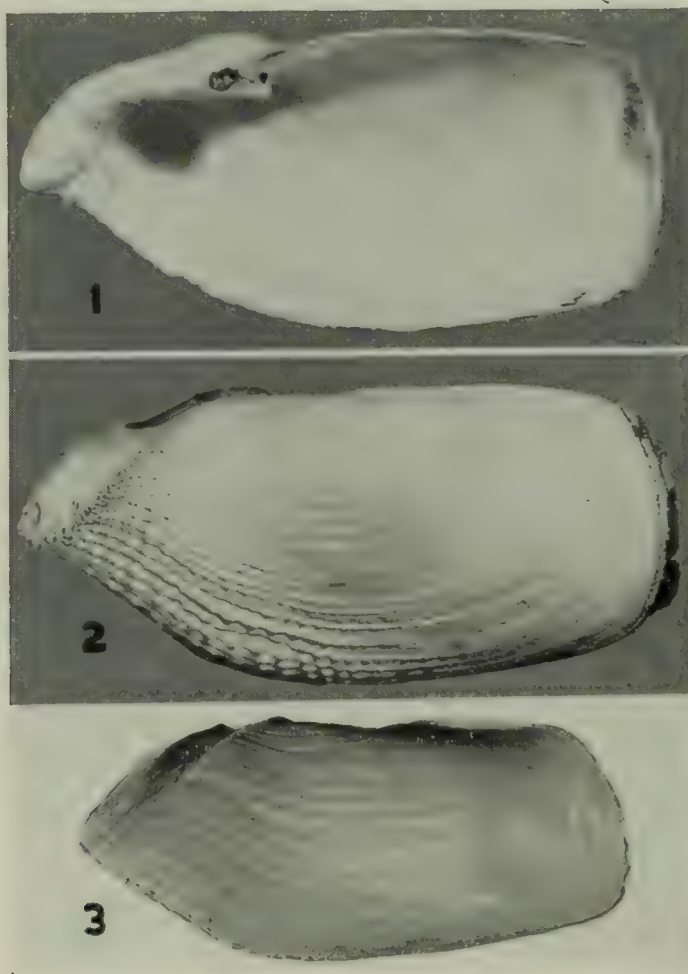


Plate 13. *Barnea truncata* Say. Figs. 1-2. Cotype, from South Carolina (about 1.2x). Fig. 1. Showing muscle scars and pallial sinus. (Apophysis lost.) Fig. 3. Accra, Gold Coast, Africa (natural size).

MCZ); Bristol (AMNH). CONNECTICUT: New Haven (USNM); Branford (MCZ). NEW YORK: Orient and Barren Island, Long Island (both R. Latham); Mattituck Creek, Mattituck and Plum Island, Long Island (both AMNH); Lido Beach, near Atlantic Beach, Long Island (M. K. Jacobson); Staten Island (MCZ: USNM); Univ. of Michigan). NEW JERSEY: Point Pleasant; Sea Isle City (both ANSP); Atlantic City (USNM; ANSP); Cape May (MCZ; USNM; ANSP; Univ. of Michigan); Great Egg Bay (USNM). VIRGINIA: Hog Island, Eastern Shore (USNM). NORTH CAROLINA: Fort Macon (MCZ); Beaufort (MCZ; USNM). SOUTH CAROLINA: Myrtle Beach; Pawleys Island; Isle of Palms; Sullivans Island; Folly Island; Magnolia Beach (all Charleston Museum); Charleston Harbor (Charleston Museum; USNM). GEORGIA: Sea Island, St. Simons Island (USNM; ANSP); Savannah (USNM). FLORIDA: St. Augustine (USNM); Daytona Beach; Cocoa (both MCZ); Flagler Beach; Cape Sable (both Univ. of Miami); Pavilion Key; Lossmans Key (both D. and N. Schmidt); Sanibel Island (MCZ; USNM); Sarasota; Anna Maria Island (both R. Stewart); Bradenton Beach (A. Koto; D. and N. Schmidt); Boca Ciega Bay, St. Petersburg (Univ. of Michigan); Clearwater Beach (ANSP); Port St. Joe (A. Merrill). TEXAS: Sand Point, Calhoun Co.; Carancahua Bay, Matagorda Bay (both USNM). HISPANIOLA: Monte Cristi, Santo Domingo (MCZ). TRINIDAD: Moruga (H. G. Kugler). BRASIL: Parada Sahy, Sepetiba Bay, Rio de Janeiro (H. S. Lopes).

EASTERN ATLANTIC. SENEGAL: Bel Tir, Dakar (Institut Français d'Afrique Noire). GOLD COAST: Accra (MCZ).

### **Barnea (Anchomasa) subtruncata Sowerby**

Plates 8 and 14 to 16

*Pholas subtruncata* Sowerby 1834, Proceedings Zoological Society London, p. 69 (Insula Platae, Columbiae Occidentalis [Ecuador]).

*Pholas spathulata* Deshayes 1843, Magasin de Zoologie (par Guérin-Méneville) (2) 5, Mollusques, pl. 79 (Seas of Chile); non *Pholas spathulata* Sowerby 1849.

*Barnea pacifica* Stearns 1871, Conchological Memoranda no. 7, p. 1 (Preliminary description); Stearns 1873, Proceedings California Academy of Science 5, p. 81, pl. 1, fig. 6, 6a-c (Alameda, San Francisco Bay, California); Stearns 1891, Proc. United States National Museum 14, p. 314.

*Barnea (Cyrtopleura) spathulata* Deshayes, Lamy 1925, Journal de Conchyliologie 69, p. 89.

*Barnea pacifica* Stearns, Hertlein and Strong 1950, Zoologica 35, p. 248.

*Distinctive characters.* Shell beaked anteriorly, broadly rounded to truncate posteriorly, with the sculpture usually lacking on the posterior slope, and with a long narrow acuminate protoplax.

*Description.* Shell reaching 67 mm. ( $2\frac{5}{8}$  inches) in length and 27 mm. (about 1 inch) in height, light in structure, beaked anteriorly, gaping at both ends and with the sculpture disappearing on the posterior slope. Umbos prominent, usually located near the anterior fourth of the shell. Umbonal reflections closely appressed over the umbos, free anteriorly. Sculpture consisting of concentric ridges and radial ribs. Concentric ridges low, usually rather widely spaced, laminated and scalloped anteriorly, becoming much weaker on the disc and evident only as growth lines on the posterior slope. Radial ribs moderate in strength on the anterior slope, weak on the disc and completely lacking on the posterior slope. Broad and rather weak imbrications are produced where the concen-

tric ridges and radial ribs cross one another. Sculpture beneath the umbonal reflection generally consists of crowded and weak concentric ridges. Interior of shell white and glazed. Muscle scars and pallial lines clearly indicated. Pallial sinus broad and extending inward nearly half the distance to the umbo. Apophyses long, narrow and curved inwardly. Protoplax lanceolate in outline, usually rather broad and truncate posteriorly, acuminate anteriorly, with a posterior nucleus and well marked growth lines. Periostracum thin on the anterior slope, rather heavier posteriorly and ranging from a straw-yellow to a dark-brown in color.

Siphons enclosed in a sheath which ranges from a dark red-brown to dark-gray in color, and usually with a narrow white tip at the posterior extremity, minutely papillose the entire length. In some specimens the dark papillose covering is worn off on the tops of the ridges, giving the specimen a mottled appearance. Incurrent siphon much larger than the excurrent and with two large dorsal ridges and ten small ridges running the entire length of the siphon internally. The interior of the siphon a deep mahogany-red posteriorly, becoming less intense as it extends forward. The exhalant siphon has one large ventral ridge and eleven small ridges internally; the dark-mahogany coloring stopping abruptly just a short distance inside the siphonal opening. These ridges terminate at the opening of the siphon in unbranched papillae. The dark periostracum extends anteriorly between the valves so that only the immediate area surrounding the foot is devoid of periostracum and is white in color. The above description of the animal was based on specimens preserved in alcohol.

length	height	ratio h:l	
73.0 mm.	21.0 mm.	3.5	Alamitos Bay, California
68.0	25.0	2.7	Anaheim Bay, California
66.5	25.0	2.6	" " "
63.0	26.5	2.3	Lectotype of <i>B. pacifica</i> Stearns
62.0	31.5	2.0	Lido Island, Newport Bay, California
61.0	22.5	2.7	Alamitos Bay, California
55.5	26.5	2.1	Anaheim Bay, California
55.5	25.5	2.1	Payta, Peru
53.5	25.0	2.1	Anaheim Bay, California

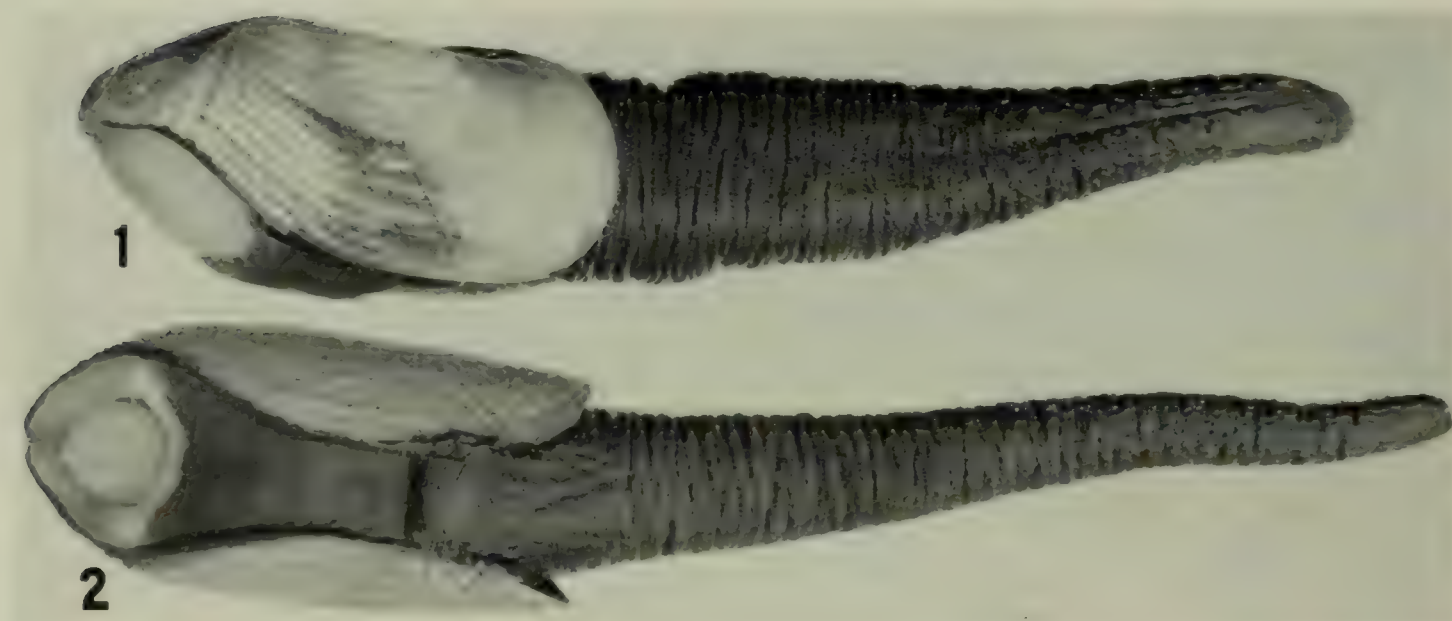


Plate 14. *Barnea subtruncata* Sowerby. Alamitos Bay, California (about natural size).  
Photograph supplied by John E. Fitch, California Fisheries Laboratory.

*Types.* The type of *Pholas subtruncata* Sowerby according to Mr. G. L. Wilkins of the British Museum is no longer in existence. The type locality is Insula Platae, Columbiae Occidentalis [Isla la Plata, Ecuador]. The type of *Pholas spathulata* Deshayes is in the Paris Museum according to Lamy (1925, p. 89) and in accordance with Lamy we here restrict the type locality to Payta, Peru. The lectotype of *Barnea pacifica* Stearns from Alameda, San Francisco Bay, California is in the United States National Museum no. 74717, paratypes are in the California Academy of Science and the Museum of Comparative Zoölogy.

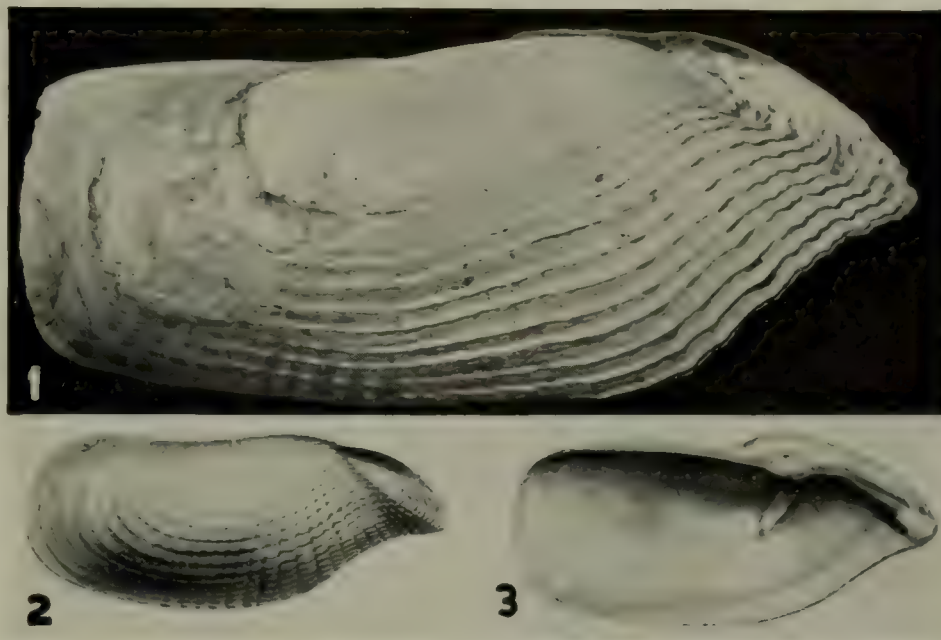


Plate 15. *Barnea subtruncata* Sowerby. Fig. 1. Lectotype of *Barnea pacifica* Stearns (= *Barnea subtruncata* Sowerby) San Francisco Bay, Alameda, California (about  $1\frac{1}{2}x$ ). Figs. 2-3. Copies of the original figures of *Barnea spathulata* Deshayes from the Magazine de Zoologie (2) 5, p. 79 (= *Barnea subtruncata* Sowerby), from Payta, Peru.

*Remarks.* *Barnea subtruncata* Sowerby is in all respects very closely related to *B. truncata* Say of the Western Atlantic. Adult shells of *B. subtruncata* Sowerby are usually larger in size and are generally slightly longer posterior to the umbo. The protoplax is usually narrower in proportion to its length and more acuminate anteriorly. In addition, the siphons of the west coast species are somewhat darker in color, as well as being more strongly ridged and colored internally. The siphons of *B. truncata* are nearly smooth internally and usually have medium brown color markings.

*Barnea subtruncata* Sowerby appears to be the earliest name for this species. Unfortunately the type is not in existence and Sowerby's description is poor. He compares *B. subtruncata* with *B. parva* of England, a species close in its relationship with the present form, and so far as is now known there is only one species in the Eastern Pacific that could be compared with the European species. There seems to be no question that *B. spathulata* Deshayes and *B. pacifica* Stearns refer to the same species, for both Stearns (1891) and Dall (1909) refer to the Peruvian species as *B. pacifica* and give the range as from California to Chile. Consequently on the basis of the material now available and considering our present knowledge of the distribution of the group, these three names all seem to refer to the same species.

*Barnea subtruncata*, like its Western Atlantic relative *B. truncata* Say, is an extremely variable species both in appearance and habit. These clams are found in mud,

clay and peat deposits, but occasionally specimens bore into soft rock or waterlogged wood. These specimens are always more or less stunted, with more produced beaks, more closely set imbricated ridges and with the posterior slope reduced and more rounded. It was probably such a specimen upon which Sowerby based his description, as he said it was boring in soft stone.

*Range.* From Newport, Oregon south to Atacama Province, Chile (Gigoux 1934, *Revista Chilena de Historia Natural* 38, p. 285).

*Specimens examined.* OREGON: Newport; Yaquina Bay (both ANSP). CALIFORNIA: Alameda, San Francisco Bay (USNM); San Francisco Bay (MCZ; ANSP); Anaheim Landing (MCZ; USNM; ANSP); San Pedro Bay (MCZ; E. P. Chace); Lido Island, Newport Bay (E. Baker); Alamitos Bay (J. E. Fitch; E. P. Chace); Bolinas (ANSP); La Playa, San Diego (USNM). MEXICO: Kino Bay, Sonora (ANSP); Mendina, Sinaloa (USNM). GALAPAGOS ISLANDS: (USNM). PERU: Payta (ANSP).

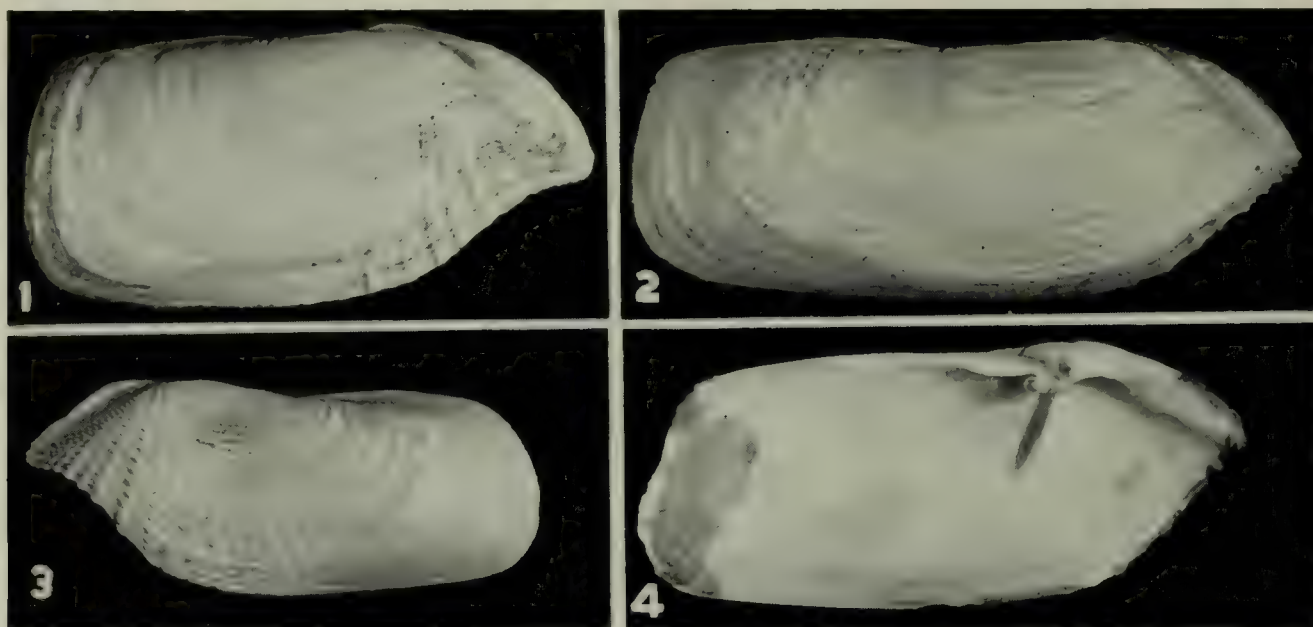


Plate 16. *Barnea subtruncata* Sowerby. Fig. 1. Payta, Peru. Figs. 2-4. Anaheim Bay, California. Figs. 1-3. These figures show the variation in the truncation of the posterior margin and the length of the post-umbonal area. Fig. 4. Internal view to show the apophysis, muscle scars and the pallial sinus (all natural size).

### Genus *Cyrtopleura* Tryon

*Cyrtopleura* Tryon 1862, *Proceedings Academy Natural Sciences Philadelphia*, p. 201.

Shells white, more or less elliptical in outline and rounded or beaked anteriorly. Pedal gape variable, ranging from a narrow slit to a broad oval. Accessory plates consisting of a protoplax and a mesoplax. Protoplax entirely chitinous or only slightly impregnated with calcium. Mesoplax transverse, in one or two pieces, calcareous and solid. Umbonal reflections simple, rather narrow, raised well above the umbos and with posterior supports. Sockets are formed in the posterior supports for the reception of the forward extension of the mesoplax. Space below the umbonal reflection not septate.

Genotype, *Pholas crucifera* Sowerby (= *Pholas cruciger* Sowerby), subsequent designation, Stoliczka 1870.

There are two subgenera in the genus *Cyrtopleura* and they may be differentiated as follows:

Shell rounded anteriorly with a slit-like pedal gape

*Scobinopholas*

Shell beaked anteriorly with an oval pedal gape

*Cyrtopleura* s.s.

### Subgenus *Scobinopholas* Grant and Gale

*Pholas* Lamarck 1801, *Système des Animaux sans Vertèbres*, Paris, p. 127 (genotype, *P. costata* Linné, monotypic); non Lamarck 1799; non Linné 1758.

*Pholas* 'Linné' H. and A. Adams 1856, *The Genera of Recent Mollusca* 2, p. 325 (genotype, *P. costata* Linné, subsequent designation, Bayle 1880); non *Pholas* Linné 1758; non Lamarck 1799.

*Scobina* Bayle 1880, *Journal de Conchyliologie* 28, p. 242 (genotype, *Pholas costatus* Linné, original designation). [New name for *Pholas* H. and A. Adams; non Linné 1758.]

*Scobinopholas* Grant and Gale 1931, *Memoirs San Diego Society Natural History* 1, p. 431 [new name for *Scobina* Bayle 1880; non *Scobina* Lepeletier 1825; non Wade 1917].

Subgenotype, *Pholas costatus* Linné, Bayle, original designation.

Shell rounded at both ends and having a long, narrow, slit-like pedal gape. Accessory plates consisting of a triangular to T-shaped, thin, largely chitinous protoplax and a heavy transverse calcareous mesoplax, which may be in one or two pieces. Umbonal reflections well separated from the surface of the umbos and supported at the posterior margins where they bend downward and form sockets for the reception of the forward extension of the mesoplax. Apophyses large, broad, and more or less spoon-shaped.

### *Cyrtopleura* (*Scobinopholas*) *costata* Linné

Plates 17 and 18

*Pholas costatus* Linné 1758, *Systema Naturae*, ed. 10, 1, p. 669 (Europe).

*Capulus shreevei* Conrad 1869, *American Journal of Conchology* 5, p. 105, pl. 13, fig. 3 (Long Island, South Carolina). [This is the apophysis only.]

*Scobina costata* Linné, Bayle 1880, *Journal de Conchyliologie* 28, p. 242.

*Holopholas* (*Scobina*) *costata* Linné, Fischer 1887, *Manuel de Conchyliologie*, Paris, p. 1133.

*Pholas* (*Barnea*, section *Scobinopholas*) *costatus* Linné, Grant and Gale 1931, *Memoirs San Diego Society Natural History* 1, p. 431.

*Distinctive characters.* Shell oval in outline, rounded at both ends and with strong radial sculpture extending the entire length. Umbonal reflections well separated from the surface of the umbos. Protoplax triangular in outline and largely chitinous. Mesoplax calcareous, transverse and very solid. Apophyses large, broadly spoon-shaped and hollow at the upper end.

*Description.* Shell oval in outline, reaching about 183 mm. (about  $7\frac{1}{4}$  inches) in length and 75 mm. (about 3 inches) in height, gibbose, rather light but strong, rounded at both ends, with a long narrow pedal gape, and with a strong radial sculpture covering nearly the entire shell. Color a chalky-white, with occasional specimens having irregular bands and markings of pink. Umbos prominent, rather broad, partially covered by the umbonal reflections and located near the anterior fourth of the shell. Umbonal reflections raised well above the surface of the umbos and having a single support at the posterior margin with sockets for the reception of the anterior projections of the mesoplax. Sculpture consisting of relatively weak concentric ridges and very strong radial ribs which exist over the entire length of the shell. Imbrications are formed where the concentric ridges

and radial ribs cross one another. These imbrications are strong on the anterior and posterior slopes but are slightly reduced over the disc. Numerous fine growth lines are visible between the concentric ridges. Interior of the shell white and glazed. On occasional specimens there may be irregular bands and markings of pink. The external sculpture is clearly visible internally, giving the inside of the valve a ribbed and pitted appearance. Pallial sinus not apparent, but anterior and posterior adductor muscle scars are fairly well marked. Occasional specimens have a ledge built out below the posterior adductor muscle scar giving more area for the attachment of the muscle. Apophyses short, wide, broadly spoon-shaped and hollow at the end. They are marked with concentric growth lines and occasionally with longitudinal ridges. Protoplax large, thin, triangular in outline, composed largely of chitin, though in older specimens it is usually impregnated with a small amount of calcium. It is pointed and grooved anteriorly, broad and occasionally slightly lobed posteriorly. It has a central nucleus and faint to rather strong growth lines. Mesoplax transverse, more or less triangular in outline, solid, calcareous and in one piece. Periostracum thin, light straw-yellow and deciduous.

Siphons united, smooth, devoid of periostracum, grayish-white to light-ivory in color with an occasional specimen having a band of buff at the distal end. Incurrent siphon slightly shorter than the excurrent siphon but with a much larger aperture. Internally the incurrent siphon has two large dorsal ridges and six to eight small ridges which extend the entire length of the siphon. These ridges terminate at the opening in minute cirri. The area between the ridges is marked with mahogany-red vermiculations. Excurrent siphon edged with brown and colored for a short distance internally with a light straw-yellow. It has one large ventral ridge and numerous smaller ridges which extend but a short distance anteriorly. Mantle and foot white to light-ivory. Foot elliptical in outline and truncate.

length	width	ratio h:l	
183.0 mm.	72.0 mm.	2.54	Mount Hope Bay, Fall River, Massachusetts
165.5	58.5	2.82	Cedar Keys, Florida
147.5	50.0	2.95	Bradenton Beach, Florida
140.0	55.5	2.52	Clam Bayou, Sanibel Id., Florida
100.5	36.0	2.82	Galveston, Texas

*Types.* According to Hanley 1855, *Ipsa Linnaei Conchyliæ*, p. 24, Linné did not have a specimen of *C. costata* in his collection. His only reference was to Gualtieri 1742, *Index Testarum Conchyliorum*, plate 105, fig. G. We select this figure to represent the type, as it is on the basis of this figure that the species has been well understood. Linné's original locality of Western Europe was corrected to America by Gmelin in the 13th edition of the *Systema Naturæ* in 1790. We here restrict the type locality to Charleston, South Carolina, a locality from which we have a good series and one from which specimens may have reached Europe at that early date.

*Remarks.* *Cyrtopleura costata* Linné is one of the largest, most easily recognized, and best known species in the Pholadidae. Adult specimens can be readily differentiated from all other species by their large size and by the coarse sculpture which covers the entire shell. Young specimens might be confused with *C. lanceolata* d'Orbigny, a much smaller species. However, this latter species has a much weaker sculpture and the radial ribs are completely lacking on the posterior slope. From *C. cruciger* Sowerby it differs by being

rounded rather than beaked anteriorly and by having strong radial ribs on the posterior slope.

*Cyrtopleura costata* Linné has a wide distribution throughout the Western Atlantic and can be very abundant in certain restricted areas. These clams live in sandy mud at and just below low water mark in protected areas, or well below the low tide line on exposed outer beaches. They can burrow to a depth of two feet or more in the mud and are capable of moving up and down in their burrows at will. When undisturbed, the siphons are usually seen extending a short distance out of the burrow.

On the west coast of Florida, in an area extending from around Bradenton south to Englewood Beach, there are a number of colonies of *C. costata* in which many of the specimens are variously marked with a bright pink. This pink coloration may be in a broad band around the umbonal area or in a band near the ventral margin. In some specimens it is restricted to the posterior slope and in a few the protoplax may be pink. To date there is no explanation for this rather unusual expression of color in a family which is otherwise practically devoid of color.

Angel Wings, as this species is popularly called, are one of our most beautiful bivalves and are much sought after by collectors. They are considered an excellent food and have appeared on the markets, particularly in Cuba, though not recently.

*Capulus shreevei* Conrad, described from Long Island, South Carolina beach drift, appears to be nothing more than the apophysis of this species.

Dall 1889, Proceedings of the Academy of Natural Sciences Philadelphia, p. 274,

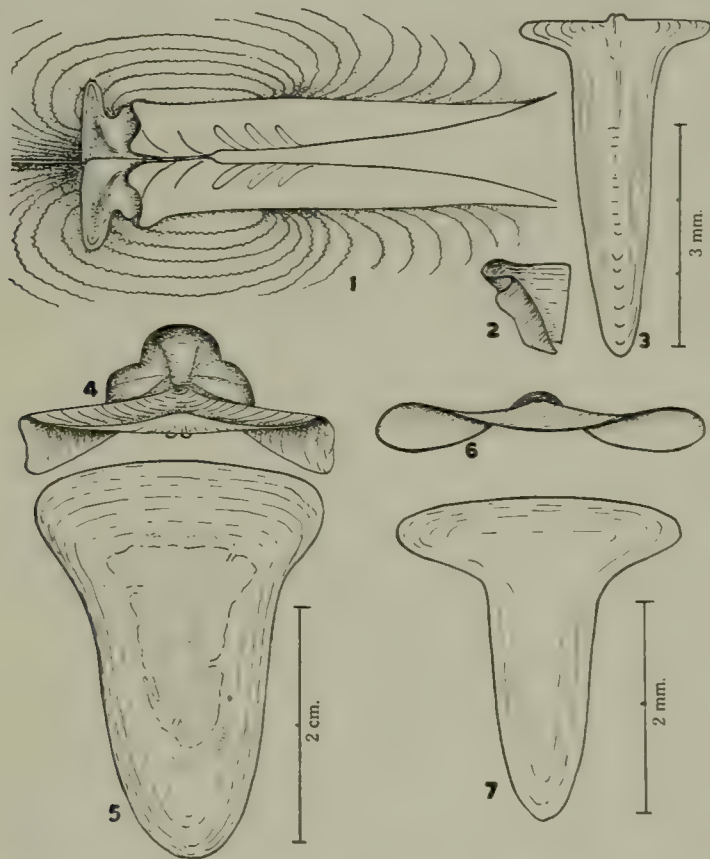


Plate 17. Dorsal plates of *Cyrtopleura*. Figs. 1-3. *Cyrtopleura lanceolata* d'Orbigny, off Cabo Polonio, Uruguay. Fig. 1. Dorsal view of umbonal region of opposed valves to show the divided mesoplax in place. Fig. 2. Dorsal view of the right half of the mesoplax. Fig. 3. Dorsal view of the thin chitinous protoplax. Figs. 4-5. *Cyrtopleura costata* Linné, Sanibel Island, Florida. Fig. 4. Dorsal view of heavy calcareous mesoplax. Fig. 5. Dorsal view of the flat, largely chitinous protoplax. The stippled portions indicate areas of calcification. Figs. 6-7. *Cyrtopleura cruciger* Sowerby, Pacific coast of Panama. Fig. 6. Dorsal view of mesoplax. Fig. 7. Dorsal view of the very thin and entirely chitinous protoplax.

gives a brief account of the gross anatomy of *C. costata*, and Kellogg (1915) discusses the ciliary mechanism.

*Range.* From Fall River, Massachusetts south through the West Indies to Rio de Janeiro, Brasil.

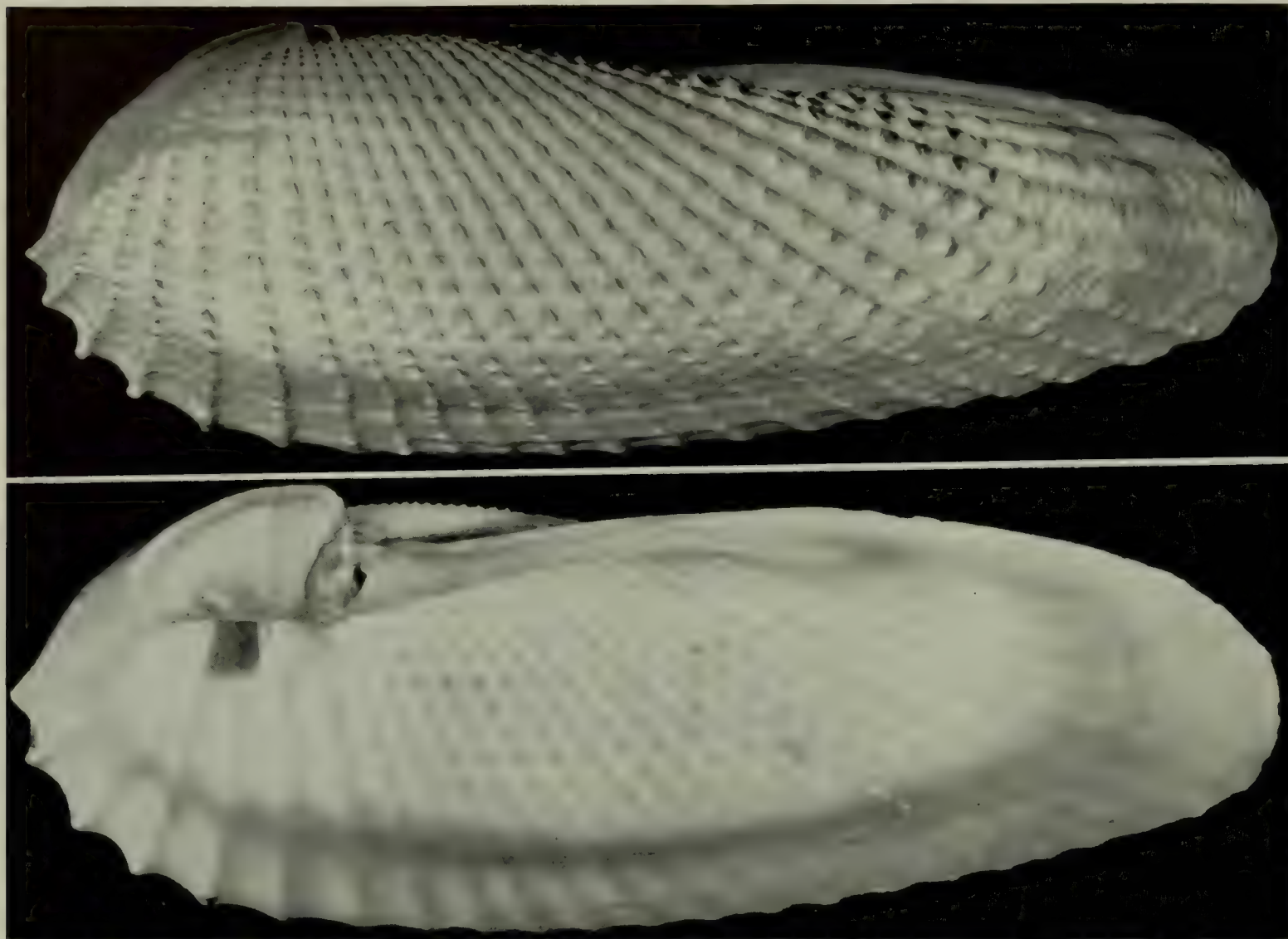


Plate 18. *Cyrtopleura costata* Linné, Bradenton, Florida. A specimen showing the band of pink color (natural size).

*Specimens examined.* MASSACHUSETTS: Fall River (J. Miller); New Bedford (MCZ; ANSP). NEW YORK: Long Beach Bay, Orient, Long Island (R. Latham). NEW JERSEY: Great Egg Harbor (USNM); Cape May (MCZ; ANSP); Sea Isle City (ANSP). DELAWARE: off New England Creek, Delaware Bay in 4 fathoms (USNM); Rehoboth Beach (ANSP). MARYLAND: off Wolf Trap Light, Chesapeake Bay in  $9\frac{1}{2}$  fathoms (USNM). VIRGINIA: Bryants Point, Severn River; Isaac's Island, Northampton County (both USNM); 10 miles south of Virginia Beach (MCZ); Buckroe Beach, Chesapeake Bay (USNM; ANSP); Hog Island, Eastern Shores (USNM). NORTH CAROLINA: Fort Macon, Beaufort; Long Beach, near South Port (both USNM); Cape Fear (ANSP). SOUTH CAROLINA: Myrtle Beach (ANSP); South Island, Georgetown County; Cape Romain; Isle of Palms; Folly Island; Bird Key (all Charleston Museum); Murrell's Inlet (A. Merrill); Bull's Island (J. L. Chamberlin); Sullivan's Island, Charleston (Charleston Mus.; MCZ; AMNH; USNM); Beaufort (MCZ; USNM); Ashe Island, Edisto River (ANSP). GEORGIA: St. Simons Island (MCZ; ANSP); Sea Island, St. Simons Island (USNM; ANSP); Savannah (USNM). FLORIDA: Atlantic Beach, near

Jacksonville (MCZ); St. Augustine (Univ. of Michigan; USNM; ANSP); Anastasia Island (ANSP); Daytona Beach (Univ. of Miami); Cape Canaveral; Cocoa Beach (both MCZ); Cape Sable (MCZ; N.E. Schmidt); Pavilion Key (MCZ); Naples; Caxambas Pass; Bunch Beach; Kice Island; Marco Island; Lemon Bay; Sarasota; Lossmans Key (all N. E. Schmidt); Sanibel Island (MCZ; USNM; ANSP); Punta Rassa (AMNH); Venice (A. Cahn); Bradenton (M. Teare; USNM); St. Petersburg (Univ. of Michigan; USNM; MCZ); Terra Ceia; Bonita Beach; Longboat Key; Sarasota (all USNM); Apalachicola Bay; Fort Myers Beach; Cape Romano (all ANSP); James Island, Franklin County (T. Pulley); Cedar Keys (USNM; ANSP). ALABAMA: Mobile Bay (MCZ); Fort Morgan; Little Lagoon, Gulf Shores (both H. I. Johnstone). MISSISSIPPI: Long Beach (ANSP); Deer Island, Biloxi (MCZ). LOUISIANA: Calaten Pass; Grand Lake (both USNM); Grand Isle (MCZ). TEXAS: Matagorda Bay; Keller Bay; Carancahua Bay (all USNM); 25 miles south of Port Arthur; near Corpus Christi (both MCZ); Galveston; High Island, Bolivar Peninsula; Boca Chica, near Brownsville (all T. Pulley); Gulf Beach, Port Isabel (L. A. Weisenhaus). MEXICO: Tuxpam; Isla del Carmen, Campeche (both M. Bourgeois); Tampico, Tamaulipas; Boquilla de Piedras; Tecolutla; Nautla; Vera Cruz; Alvarado, all of the last four in the State of Vera Cruz (all T. Pulley). CUBA: Habana (MCZ); Mariel, Pinar del Río (C. G. Aguayo). HISPANIOLA: Monte Cristi, Santo Domingo (MCZ). PUERTO RICO: Río Herrera near Loisa Vieja; Ponce (both MCZ). LESSER ANTILLES: Moruga, Trinidad (H. G. Kugler). BRITISH GUIANA: 4 miles east of Georgetown (H. G. Kugler). DUTCH GUIANA: Matappica (C. Bayer). BRASIL: Ilha de Itaparica, Bahía; Ilha do Cardoso, Cananea, São Paulo (both de Oliveira); Nova Almeida (MCZ); Aracaju, Sergipe; Parada Sahy, Sepetiba Bay, Rio de Janeiro (both H. S. Lopes); Rio de Janeiro (USNM).

***Cyrtopleura (Scobinopholas) lanceolata* d'Orbigny**

Plates 17 and 19

*Pholas lanceolata* d'Orbigny 1846, Voyage Amérique Méridionale 5, pt. 3, Mollusques, p. 497, pl. 77, figs. 18-19 (L'Ensenada de Ros au Sud du Rio Negro, Patagonie).

*Barnea lanceolata* d'Orbigny, Tryon 1862, Proc. Academy Natural Sciences Philadelphia 14, p. 208; Carcelles 1944, Revista del Museo de la Plata (n.s.) Zoologia 3, p. 295, pl. 14, fig. 110.

*Distinctive characters.* Shell lanceolate in outline and rounded at both ends. Radial sculpture weak and usually entirely lacking on the posterior slope. Protoplax T-shaped,

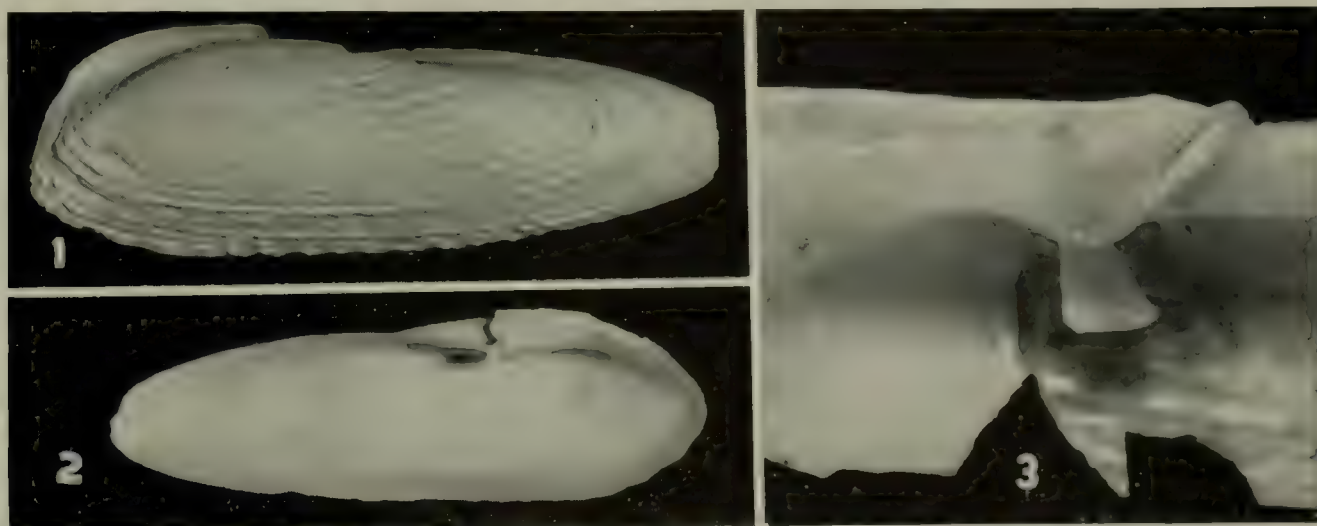


Plate 19. *Cyrtopleura lanceolata* d'Orbigny. Figs. 1-2. Monte Hermoso, Bahía Blanca, Buenos Aires, Argentina (natural size). Fig. 3. Mar del Plata, Buenos Aires, Argentina (hinge area enlarged to show apophysis).

entirely chitinous and very thin. Mesoplax in two pieces, calcareous and solid. Apophyses short, broad and flattened at the free end.

*Description.* Shell lanceolate in outline, reaching 69 mm. (about  $2\frac{3}{4}$  inches) in length and 21.5 mm. (about  $\frac{7}{8}$  inch) in height, thin, rounded to slightly angled anteriorly and narrowly rounded posteriorly. Pedal gape long and narrow, posterior gape slight. Color a dull chalky-white. Umbos prominent and located near the anterior third of the shell. Umbonal reflections well separated from the umbos, and with posterior supports which have sockets for the reception of the mesoplax. Sculpture consisting of well marked concentric ridges and rather weak radial ribs which are indicated mainly by the slight imbrications at the point where the radial ribs and concentric ridges cross. Radial ribs are lacking on the posterior slope in adult specimens but the concentric ridges are well marked. In young specimens, however, well developed imbrications are evident the entire length of the shell. Interior of the shell white and glazed. Pallial sinus wide and deep, extending inward about two thirds the distance to the umbo. Pallial line and muscle scars clearly indicated in older specimens. Apophyses short, broad, rather thin, fragile and flattened at the free end. Protoplax exceedingly thin, entirely chitinous and T-shaped. This protoplax is so thin and so closely attached to the muscle that it is easily overlooked. It curves slightly downward at its posterior extremity, has a posterior nucleus and faint growth lines which are visible when viewed with transmitted light. Mesoplax transverse, calcareous and in two parts. The anterior extensions of the mesoplax fit into sockets formed by the folds of the posterior supports of the umbonal reflections. Periostracum thin, light straw-yellow and deciduous.

Siphons united and covered by a light-brown, minutely papillose, chitinous sheath. Incurrent siphon with seven to eight large and several small, branched cirri surrounding the aperture. The excurrent siphon lacks cirri. Pedal gape and foot elliptical in outline. Foot and mantle white to light-ivory in color.

length	width	ratio h:l	
69.0 mm.	21.5 mm.	3.2	Monte Hermoso, Bahía Blanca, Buenos Aires, Argentina
56.5	18.0	3.1	Playa de Punta Medenas, Buenos Aires, Argentina

*Types.* The holotype of *Pholas lanceolata* d'Orbigny is in the British Museum, according to Gray 1854, List of the Shells of South America in the Collection of the British Museum Collected and Described by M. Alcide d'Orbigny, p. 55. The type locality is Ensenada de Ros south of Río Negro, Patagonia, Argentina.

*Remarks.* *Cyrtopleura lanceolata* d'Orbigny differs from *C. cruciger* Sowerby, with which it might be confused, by having the anterior end of the valves rounded rather than moderately beaked, by being lanceolate rather than oval in outline, by having a much weaker sculpture and by having the mesoplax in two pieces. From young specimens of *C. costata* Linné it may be distinguished by its weak radial sculpture which is lacking on the posterior slope, by its flat rather than spoon-shaped apophyses, by its proportionately longer anterior slope, and also by having the mesoplax in two pieces.

We know nothing of the biology of this species. It has seldom been recorded in the literature and there are but few specimens in the museums of this country. However, through the kindness of A. Carcelles, formerly of the Museo Nacional de Argentina, we have had a fine series to study.

*Range.* From Santos, Brasil south to the Gulf of San Matias, Argentina.

*Specimens examined.* BRASIL: Santos (USNM): Frances Island, north of Santa Catharina Island, Estado Santa Catharina (H. Lopes). URUGUAY: off Cabo Polonio (S. Lat.  $34^{\circ}42'$ ; W. Long.  $54^{\circ}10'$ ) (A. Carcelles). ARGENTINA: Mar del Plata, Buenos Aires; Monte Hermoso, Bahía Blanca, Buenos Aires; Playa de Punta Medanos, Río Negro (all A. Carcelles); Buenos Aires (USNM); Carmen de Patagones, Buenos Aires (Univ. of Michigan: USNM); Río Negro (Redpath Museum, Montreal: USNM).

### Subgenus *Cyrtopleura* Tryon

*Cyrtopleura* Tryon 1862, Proceedings Academy Natural Sciences Philadelphia 14, p. 201.

Shell beaked anteriorly, rounded posteriorly, and having a broad oval pedal gape. Accessory plates consisting of a more or less T-shaped, chitinous protoplax and a transverse, calcareous mesoplax. Umbonal reflections well separated from the umbos and supported at the posterior margins where they curve downward and form sockets for the reception of the anterior extensions of the mesoplax. Apophyses broad and flattened.

Subgenotype, *Pholas crucifera* Sowerby (= *Pholas cruciger* Sowerby), subsequent designation, Stoliczka 1870.

### *Cyrtopleura* (*Cyrtopleura*) *cruciger* Sowerby

Plates 17, 20 and 21

*Pholas cruciger* Sowerby 1834, Proceedings Zoological Society London, p. 69 (Puna Island in Gulf of Guayaquil and Bay of Caraccas [Caráques], West Colombia [Ecuador] and in the Gulf of Nocoioy [Nicoya], Costa Rica).

*Pholas crucifera* Sowerby 1849, Thesaurus Conchyliorum 2, pt. 10, p. 489 [error for *cruciger* Sowerby].

*Pholas crucigera* Sowerby 1849, Thesaurus Conchyliorum 2, pt. 10, pl. 104, figs. 24-26 [error for *cruciger*, on plate caption only].

*Pholas* (*Cyrtopleura*) *crucifera* Sowerby, Tryon 1862, Proceedings Academy Natural Sciences Philadelphia, 14, p. 201.

*Cyrtopleura exilis* Tryon 1870, American Journal of Conchology 5, p. 170, pl. 14, fig. 2 (Ins. St. Croix [Virgin Islands], West Indies).

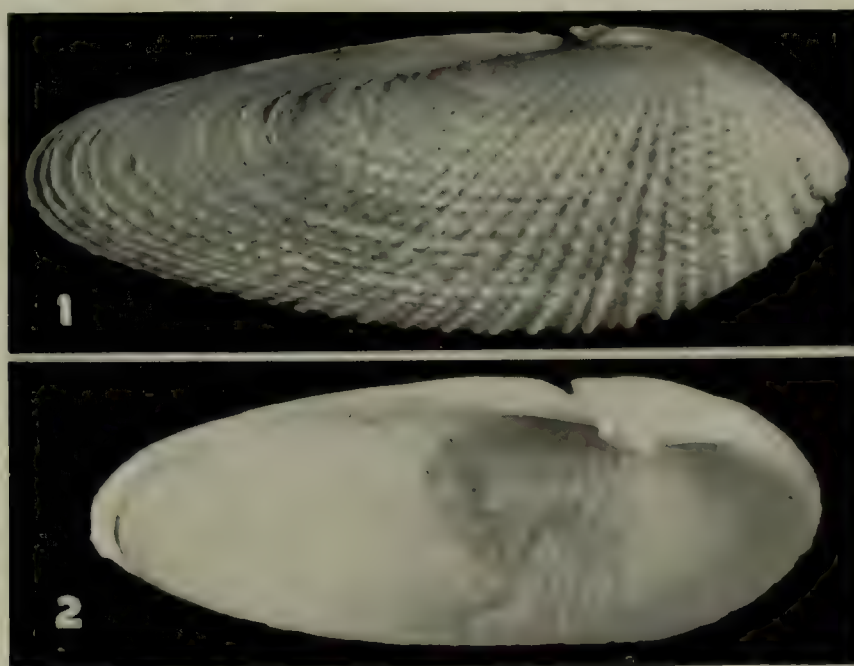


Plate 20. *Cyrtopleura exilis* Tryon (= *cruciger* Sowerby) St. Croix, Virgin Islands. Lectotype, ANSP 51040 (about 3x).

*Distinctive characters.* Shell beaked anteriorly, narrowly rounded posteriorly and with concentric sculpture extending over the entire surface of the shell. Radial sculpture strong on the anterior slope, becoming weak on the disc and lacking on the posterior slope. Accessory plates consisting of a very thin, chitinous, more or less T-shaped protoplax and a transverse mesoplax.

*Description.* Shell oval in outline, reaching about 44 mm. ( $1\frac{3}{4}$  inches) in length and 18 mm. (about  $\frac{5}{8}$  inch) in height, thin but strong, rounded posteriorly and with small rounded beaks anteriorly. Pedal gape large, generally oval in outline and tapering at both ends. Color a dull chalky-white to light-brown. Umbos prominent and located near the anterior third of the shell. Umbonal reflections well separated from the umbos and with a single support at the posterior margins where sockets are formed for the reception of the anterior projections of the mesoplax. Posterior to the umbo, the dorsal margin of the valve is reflected upward and outward forming a sharp angle with the margin of the umbonal reflection. Sculpture consisting of rather strong concentric ridges and radial ribs. Concentric ridges are well marked throughout the length of the shell, while the radial ribs are strong on the anterior slope, weak on the disc, and lacking on the posterior slope. Imbrications are formed where the concentric ridges and radial ribs cross one another. These imbrications are prominent on young and perfect specimens, but on worn adult specimens they may be indicated only as slightly roughened wavy lines. Sculpture below the umbonal reflection consisting of crowded concentric ridges. Interior of shell white and glazed and with the radial ribs clearly showing on the anterior portion. Pallial sinus broad and deep, extending inward about  $\frac{2}{3}$  the distance to the umbo. Apophyses short, broadened and flattened, curved sharply inward and solid at the upper end. Protoplax very thin, entirely chitinous and generally more or less T-shaped. Mesoplax transverse, strong, calcareous and in one piece. Periostracum exceedingly thin, light straw-yellow and deciduous.

The siphons may be extended 3 to 4 times the length of the shell; they are light-tan in color and minutely papillose. Incurrent siphon with 6 large and numerous small branched cirri. Foot elliptical in outline, truncate and white to light-ivory in color. Mantle white to light-ivory. The above description of the soft parts is based upon preserved material.

length	height	ratio h:l	
36.0 mm.	17.5 mm.	2.0	Panama
44.0	18.0	2.4	"
38.7	16.5	2.3	"

*Types.* The types of *Pholas cruciger* Sowerby are in the British Museum. Sowerby listed three localities in his original description: Puna Island in the Gulf of Guayaquil and the Bay of Caraccas [Caráques], Colombia [Ecuador] and in the Gulf of Nocoio [Nicoya], Costa Rica. We here restrict the type locality to the Gulf of Nicoya, Costa Rica, a locality from which we have seen specimens. The lectotype of *Cyrtopleura exilis* Tryon is in the Academy of Natural Sciences of Philadelphia, no. 51040. The type locality of St. Croix, Virgin Islands, we believe, is in error.

*Remarks.* *Cyrtopleura cruciger* Sowerby is a very distinctive species not closely related to any other in this group. It differs from young specimens of *C. costata* Linné by lacking the radial ribs on the posterior slope, by having the anterior margin of the shell

beaked and by having the apophyses solid at the upper end. There are also considerable differences in the dorsal plates which can best be seen by studying the figures. From *C. lanceolata* d'Orbigny it differs by being oval rather than lanceolate in outline, by having a much stronger sculpture, by being beaked anteriorly, and by having the mesoplax in one piece.

*Cyrtopleura cruciger* Sowerby is apparently a rare species throughout its range and is restricted in its ecological distribution to areas of soft stone. We have seen several specimens of a soft stone taken at Panama with the shells of *C. cruciger* still in place. They generally bore to a depth of about twice the length of the shell and make a rather snug burrow.

Philippi (1851, *Abbildungen und Beschreibungen Conchylien* 3, p. 129) was in error when he gave one of the localities for *cruciger* as "sinus Caraccas [sic] in Mari Antillarum." Sowerby in his original description stated that this species, which was collected by Hugh Cuming, came from the "island of Puna in the Gulf of Guayaquil; in soft stone at low water in the Bay of Caraccas; both in West Colombia."<sup>1</sup> This Eastern Pacific species is not known from the Western Atlantic. *Cyrtopleura exilis* Tryon is definitely this species and the locality St. Croix is certainly in error.

*Range.* From Guaymas, Sonora, Mexico south to Puna Island in the Gulf of Guayaquil, Ecuador.

*Specimens examined.* MEXICO: Guaymas, Sonora (USNM). COSTA RICA: Isla San Lucas, Gulf of Nicoya (USNM). PANAMA: (Redpath Museum; C. M. Dumbauld: MCZ); Panama City (J. Zetek); Old French Canal, Canal Zone (ANSP).

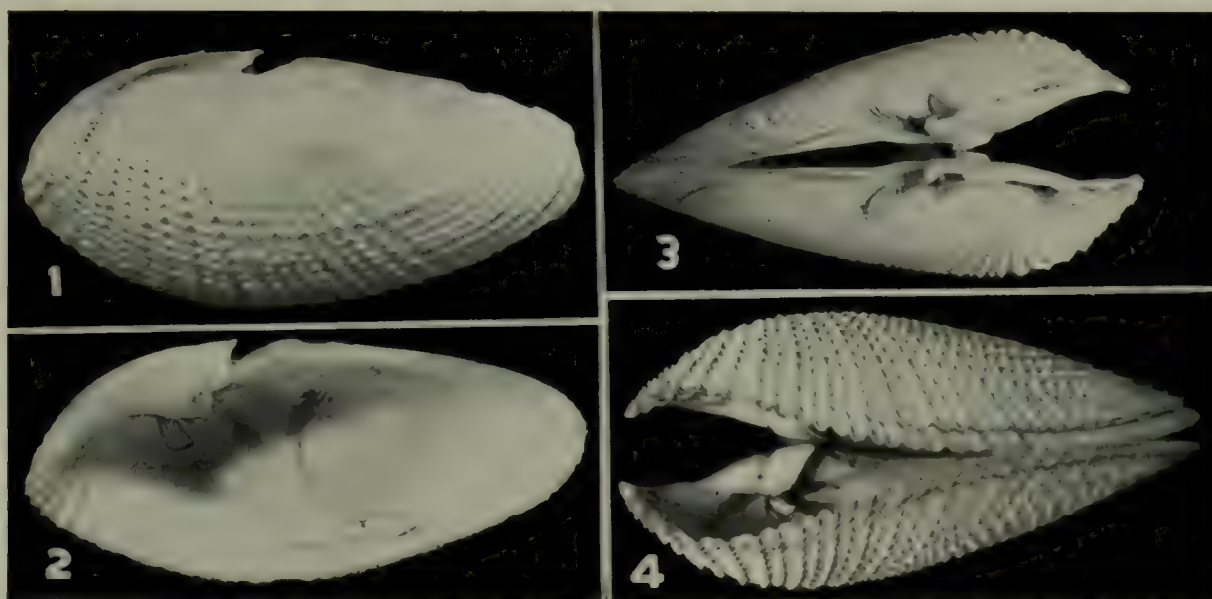


Plate 21. *Cyrtopleura cruciger* Sowerby. Figs. 1-4. Panama (all natural size). Fig. 1. External view showing the umbonal reflection with its posterior support and the notch formed by the reflection of the dorsal margin of the valve posterior to the umbos. Fig. 2. Interior view showing the broad, flat apophysis, the muscle scars and pallial sinus. Fig. 3. Dorsal view of opposed valves showing the narrow umbonal reflection and the supports. Fig. 4. Ventral view of opposed valves showing the beaks and the pedal gape.

<sup>1</sup> The Bay of Carácas in which Hugh Cuming collected was in Colombia, now Ecuador (South Latitude 0°30'). This place is now known as Bahía de Caráques. Clench 1945, *Occasional Papers on Mollusks* 1, p. 26.

Genus **Pholas** Linné

*Pholas* Linné 1758, Systema Naturae, ed. 10, 1, p. 669; Lamarck 1799, Prodrome d'une Nouvelle Classification des Coquilles [in] Mémoires de la Société d'Histoire Naturelle Paris, p. 90; *non* Lamarck 1801.

Genotype, *Pholas dactylus* Linné, subsequent designation, Children 1822.

Shells more or less elliptical in outline, with double, septate umbonal reflections and three accessory dorsal plates. Protoplax oval to quadrangular in outline, thin, calcareous, in one part or divided longitudinally into two parts. Mesoplax transverse and more or less triangular in outline, calcareous and solid in structure. Metaplax long and narrow. Shell beaked or rounded anteriorly. Sculpture extending over the entire shell or lacking on the posterior slope.

The genus may be divided into three subgenera on the basis of the above characters and may be keyed out as follows:

- |   |                                 |
|---|---------------------------------|
| 1. Protoplax divided into two parts   | 2                               |
| Protoplax in one piece  | <i>Monothyra</i> (Indo-Pacific) |
| 2. Shell beaked anteriorly, nuclei of the divided protoplax located near the posterior outer margin | <i>Pholas</i> s.s.              |
| Shell rounded anteriorly, nuclei of the divided protoplax located near the anterior inner margin    | <i>Thovana</i>                  |

Subgenus **Pholas** Linné

*Pholas* Linné 1758, Systema Naturae, edition 10, 1, p. 669; Lamarck 1799, Prodrome d'une Nouvelle Classification des Coquilles [in] Mémoires de la Société d'Histoire Naturelle Paris, p. 90; *non* Lamarck 1801.

*Hypogaea* Poli 1791, Testacea Utriusque Siciliae Eorumque Historia et Anatome 1, Introduction, p. 29 [name for soft parts only].

*Hypogaeoderma* Poli 1795, Testacea Utriusque Siciliae Eorumque Historia et Anatome 2, pp. 251, 257 (type, here selected, *Pholas dactylus* Linné).

*Dactylina* Gray 1847, Proceedings Zoological Society London, p. 187 (genotype, *Pholas dactylus* Linné, monotypic); *non* *Dactylina* Zborzewski 1843.

*Xylotrya* 'Leach' Menke 1830, Synopsis Methodica Molluscorum, p. 121 (genotype, *Pholas dactylus* Linné, subsequent designation, Clench and Turner 1946).

*Pragmopholas* Fischer 1887, Manuel de Conchyliologie, p. 1133 (genotype, here selected, *Pholas dactylus* Linné).

*Phragmopholas* 'Fischer' Dall 1898, Transactions Wagner Free Institute of Science, Philadelphia, 3, p. 814 [error for *Pragmopholas* Fischer].

Subgenotype, *Pholas dactylus* Linné, subsequent designation, Children 1822.

The subgenus *Pholas* is characterized by having the shells beaked anteriorly, by having the protoplax divided longitudinally into two parts, and by having the nuclei of the divided protoplax near the posterior outer margin.

This subgenus is restricted in its distribution to the Eastern Atlantic. The following description of *Pholas dactylus* Linné, the genotype of *Pholas*, is included for the clarification of the genus.

**Pholas (Pholas) dactylus Linné****Plates 22 and 23**

*Pholas dactylus* Linné 1758, Systema Naturae ed. 10, 1, p. 669 (Europe); Bucquoy, Dautzenberg and Dollfus 1896, Mollusques Marins du Roussillon 2, p. 609, pl. 87.

*Pholas muricatus* DaCosta 1778, Historia Naturalis Testaceorum Britanniae, p. 244, pl. 16, fig. 2 (shores of Great Britain and Ireland).

*Pholas dactilus* 'Linné' Born 1778, Index Rerum Naturalium Musei Caesarei Vindobonensis, p. 7 [error for *dactylus* Linné].

*Hypogaea verrucosa* Poli 1795, Testacea Utriusque Siciliae Eorumque Historia et Anatome 2, p. 251 [name given to the soft parts only].

*Hypogaeoderma dactylus* Linné, Poli 1795, Testacea Utriusque Siciliae Eorumque Historia et Anatome 2, p. 257.

*Pholas hians* Solander 1786, Catalogue of the Portland Museum, p. 102, lot 2240; p. 174, lot 3736 [nomen nudum].

*Pholas hians* 'Solander' Pulteney 1799, Catalogue of the Birds, Shells, etc. of Dorsetshire, p. 26 [in Hutchins' History of the County, Dorset, London. (Dorset coast at Weymouth [sic], Swanage and the north shore at Poole)]; non *Pholas hians* Gmelin 1790.

*Pholas callosa* Lamarck 1818, Animaux Sans Vertèbres 5, p. 445 (Bayonne [France]); Lamy 1922, Bulletin Museum National d'Histoire Naturelle, Paris, 28, p. 245.

*Dactylina dactylus* Linné, Gray 1847, Proceedings Zoological Society London, p. 187.

*Pholas dactylus* var. *gracilis* Jeffreys 1865, British Conchology 3, p. 105 (Exmouth, England).

*Pholas dactylus* var. *decurtata* Jeffreys 1865, British Conchology 3, p. 105 (Sussex, England).

*Pholas dactylina* Locard 1886, Prodrome de Malacologie Française, Catalogue Général des Mollusques Vivantes de France. Mollusques Marins, p. 365 [in foot note].

*Pragmopholas (Dactylina) dactylus* Linné, Fischer 1887, Manuel de Conchyliologie, p. 1133, fig. 863.

**Distinctive characters.** Shell white, beaked anteriorly, rounded posteriorly, with double, septate umbonal reflections and having a divided protoplax, a triangular meso-

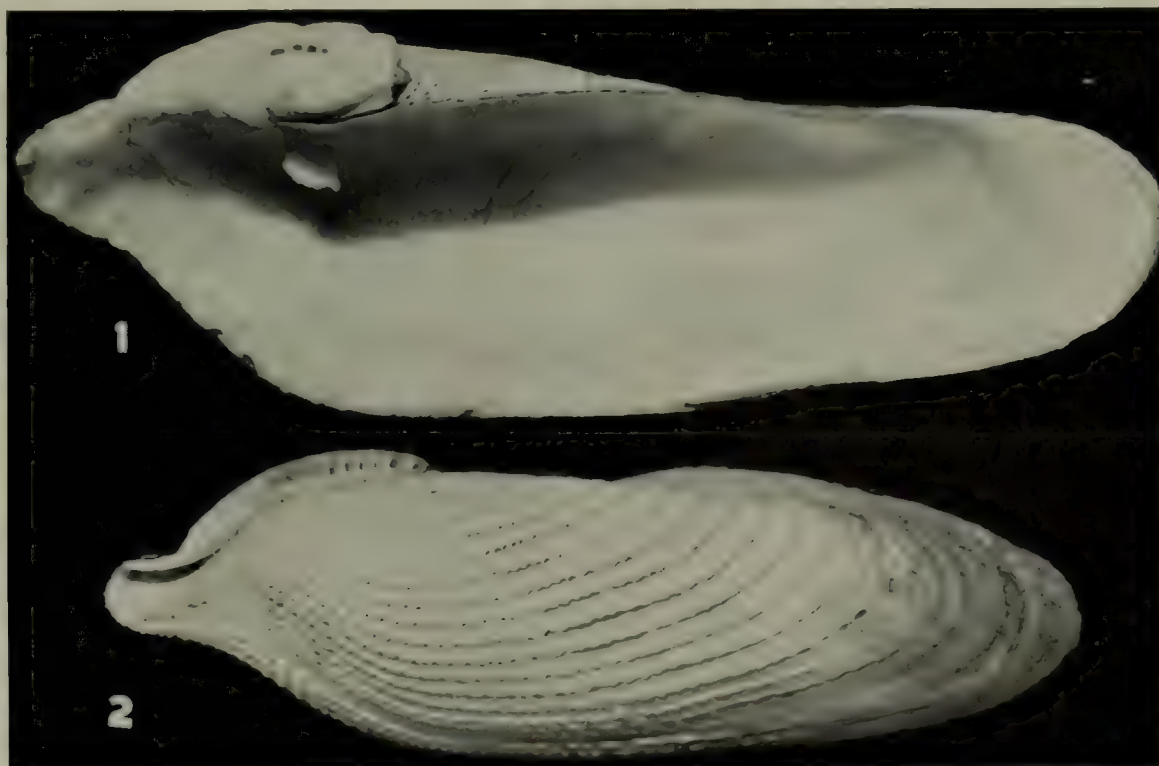


Plate 22. *Pholas dactylus* Linné. Figs. 1-2. Island of Malta (slightly reduced). Fig. 1. Internal view showing the broad flat apophysis, muscle scars and deep pallial sinus. Fig. 2. External view showing the septate umbonal reflection, the beak, and the pronounced concentric sculpture.

plax, and a long narrow metaplast. Nuclei of the divided protoplast located near the outer posterior margin.

*Description.* Shell subelliptical in outline, reaching about 130 mm. (about 5 inches) in length and 41 mm. (about 1½ inches) in height. Shell thin but strong, beaked anteriorly, rounded posteriorly, with septate umbonal reflections. The sculpture is often weak or absent on the posterior slope. Color a dull chalky-white to grayish-white. Umbos prominent, located near the anterior fourth of the shell and covered by double septate umbonal reflections. There are 10 to 14 septa in the average specimen about 3 inches long. Umbonal reflections free for a short distance over the beaks but closely appressed over the umbos and posterior to them. Sculpture consisting of laminated concentric ridges and radial ribs. Laminated ridges well marked for the entire length of the shell in young specimens, but in older specimens and especially those boring into hard rock they may be entirely lacking on the posterior slope. Radial ribs prominent on the anterior slope but becoming weak over the disc and entirely lacking on the posterior slope. Strong imbricated scales are produced where the concentric ridges and radial ribs cross one another. However, these may be worn down to undulating ridges in specimens boring into a hard substratum. In young specimens the concentric ridges are rather widely spaced and prominent the entire length of the shell. Very young specimens may be imbricate even on the posterior slope. Interior of the shell white and glazed with a slight indication of the radial ribs and concentric ridges showing through. Umbonal reflections usually worn away at the point of contact and rotation of the two valves. Muscle scars and pallial sinus well marked. Pallial sinus broad and deep, extending inwards two thirds the distance to the umbos. Apophyses rather short, solid and strong, flattened and often ridged on the free ends. Accessory plates three, a divided protoplast, a transverse mesoplast, and a long narrow metaplast. Protoplast calcareous, fragile, divided through the middle longitudinally, truncate posteriorly, acuminate anteriorly, with well marked concentric growth lines and with the nuclei near the posterior outer margins. Mesoplast, as shown in plate 23, calcareous and solid. Metaplast long and narrow, rather thin and faintly marked with growth lines.

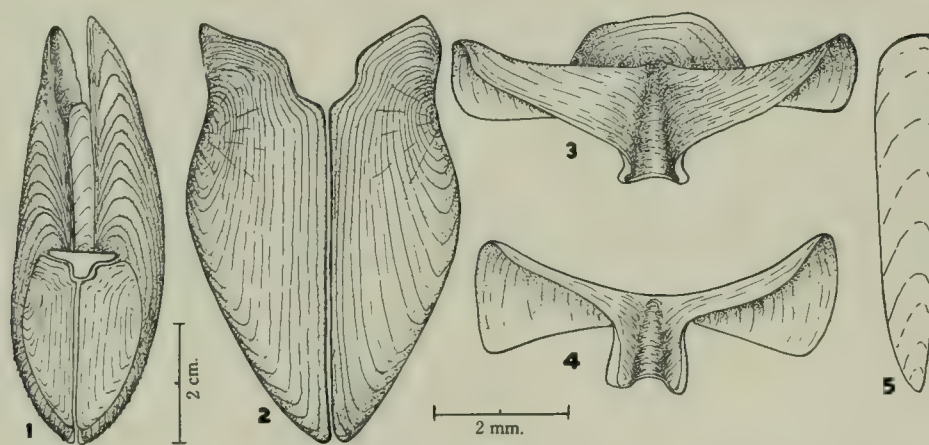


Plate 23. The dorsal plates of *Pholas dactylus* Linné. Fig. 1. Nantes, France. Dorsal view of an entire specimen to show the normal position and arrangement of the dorsal plates. Figs. 2-5. St. Juliac, Dinard, France. Individual plates of a young specimen. Fig. 2. Dorsal view of the divided protoplast showing the faint growth lines and the location of the nuclei near the posterior outer margins. Fig. 3. Dorsal view of the mesoplast tipped forward to show the basal flange. Fig. 4. Mesoplast in normal position. In young specimens this has a deeply curved posterior margin, while in older specimens it is nearly straight as shown in Fig. 1. Fig. 5. Dorsal view of the metaplast showing the fine growth lines.

Siphons extending at least one to two times the length of the shell, white to light-ivory in color, papillose and devoid of periostracum except for a small band near the posterior margin of the shell. Incurrent siphon nearly twice the diameter of the excurrent siphon and with 10 to 14 small-branched cirri surrounding the aperture. Excurrent siphon lacking cirri. We have seen only preserved specimens of this species but the gross morphology has been figured by Poli, Deshayes, and DuBois.

length	height	ratio h:l	
149.5 mm.	41.5 mm	3.5	Malta (fish market)
132.0	43.0	3.1	Malta
113.0	33.0	3.4	Smyrna, Turkey
105.0	32.0	3.3	" "
94.0	32.0	2.9	Cornwall, England
81.0	28.5	2.8	Pouliguen, near Nantes, France
28.0	14.0	2.0	La Rochelle, France

*Types.* According to Hanley (1855, *Ipsa Linnaei Conchylia*, p. 24) the types of *Pholas dactylus* are in the Linnean Collection. The type locality given by Linné was Europe. The location of the type of *Pholas muricatus* DaCosta is unknown. The types of *P. hians* Pulteney, *P. dactylus* var. *gracilis* Jeffreys and *P. dactylus* var. *decurtata* Jeffreys are probably in the British Museum.

*Remarks.* *Pholas dactylus* Linné is a very variable species both in its appearance and in its habitat. The substrata in which it has been found boring vary from such easily worked material as sand, peat, marl, and waterlogged wood to slate, sandstone and schistose rocks. Jeffreys states that his variety *gracilis* was boring in pure sand and as a consequence it was a thin and delicate shell. His *decurtata*, which he described as stunted and solid with close and usually effaced sculpture, was found in hard rocks. It is this wide range of habitat that has been responsible for these ecological forms and has resulted in the extensive synonymy given above.

*Pholas dactylus* Linné is perhaps the most famous of all pholads. It was well known to the early naturalists of Europe who were fascinated by its luminescent properties and its ability to bore into hard rock. Much has been written on this and a summary of some of the work is given in the introduction to this paper. In the early Mediterranean countries *Pholas dactylus* Linné was considered a great delicacy and it is still eaten by some today.

*Range.* From the Firth of Forth, Scotland (Hanley 1853, p. 11) south along the Eastern Atlantic coast to Oran, Algeria; the Mediterranean, Adriatic, and Aegean Seas.

*Specimens examined.* BRITISH ISLES: Tenby, Wales; Cornwall, South Devon; Kent County (all MCZ); Broadstairs (Charleston Museum). FRANCE: Caleu, near La Rochelle; coast of Pouliguen, near Nantes; Nantes; Rouen; St. Juliac, Dinard (all MCZ); La Rochelle; Touraine (both USNM). ITALY: Porto Maurizio; Gulf of Naples (both MCZ). MALTESE ISLANDS: Senglea Point, Malta (MCZ). TURKEY: Smyrna (MCZ). ALGERIA: Oran (MCZ).

Subgenus **Thovana** Gray

*Thovana* 'Leach' Gray 1847, Proceedings Zoological Society London, p. 187 (subgenotype, *Pholas oblongata* Say, monotypic).

*Gitocentrum* Tryon 1862, Proceedings Academy Natural Sciences Philadelphia **14**, pp. 203-204 (subgenotype, here selected, *Pholas campechiensis* Gmelin).

Shell rounded anteriorly, with septate umbonal reflections and three accessory plates. Protoplax divided into two parts longitudinally with the nuclei anterior and more or less centrally located. Mesoplax small and transverse. Metaplax thin, long and narrow.

The subgenus *Thovana* is restricted in its distribution to the Western Atlantic and the Eastern Pacific.

Subgenotype, *Pholas oblongata* Say (= *P. campechiensis* Gmelin), monotypic.

**Pholas (Thovana) campechiensis** Gmelin

Plates 24 and 25

*Pholas campechiensis* Gmelin 1790, Systema Naturae, edition 13, **1**, p. 3216 (Sinu Campechiensi).

*Pholas oblongata* Say 1822, Journal Academy Natural Sciences Philadelphia **2**, p. 320 (Georgia, Carolina and East Florida); non *oblongata* Tuomey and Holmes 1858.

*Thovana oblongata* Say, Gray 1847, Proceedings Zoological Society London, p. 187.

*Dactylina* (*Gitocentrum*) *campechensis* 'Gmelin' Tryon 1862, Proceedings Academy Natural Sciences Philadelphia **14**, p. 204 [error for *campechiensis* Gmelin].

*Pholas candeana* d'Orbigny 1842 [in] Sagra, Histoire de L'Ile de Cuba, Mollusques **2**, p. 215, pl. 25, figs. 18-19; (Martinique; Habana, Cuba; Florida).

*Pragmopholas* (*Gitocentrum*) *campechiensis* Gmelin, Fischer 1887, Manuel de Conchyliologie, p. 1133.

*Distinctive characters.* Shell white, rounded at both ends, with septate umbonal reflections, with the concentric sculpture extending the entire length of the shell and with three accessory plates consisting of a divided protoplax, a mesoplax and a metaplax.

*Description.* Shells subelliptical in outline, reaching about 110 mm. (about  $4\frac{3}{8}$  inches) in length and 35 mm. ( $1\frac{3}{8}$  inches) in height, thin, fragile, rounded, gaping slightly at both ends, and with the sculpture extending over the entire shell. Color a chalky-white to gray-white. Umbos prominent, located near the anterior fourth of the shell and covered by double, septate umbonal reflections. There are 10 to 14 septa in the average specimen of about 3 inches in length. Umbonal reflections free anterior to the umbos, but closely appressed over the umbos and posterior to them. Sculpture consisting of laminated, concentric ridges and radial ribs. Concentric ridges strong on the anterior slope, becoming somewhat weaker over the disc, and in adult specimens, usually weak and occasionally absent on the posterior slope. Radial ribs prominent on the anterior slope, becoming weak on the disc and usually disappearing on the posterior slope. Imbricated scales are formed where the concentric ridges and radial ribs cross one another. In young specimens the concentric ridges are widely spaced, very prominent and imbricate, even on the posterior slope. Sculpture below the umbonal reflections consisting of low, smooth, concentric ridges. Interior of shell white and glazed. Radial ribs and concentric ridges usually visible internally, especially on the anterior slope. Umbonal reflections usually worn away at the point of contact of the two valves. Muscle scars and pallial line well marked. Pallial sinus broad, deep and extending inward nearly two thirds

the distance to the umbo. Apophyses fragile, short and broad, and projecting from beneath the umbo at a sharp angle posteriorly. Accessory plates three, a double, nearly rectangular protoplax, a transverse mesoplax, and an elongate narrow metaplax. Protoplax divided through the middle longitudinally, truncate posteriorly, and acuminate anteriorly. The nuclei of the divided protoplax are anterior and nearly centrally located. Mesoplax small, and a broad, flattened triangle in outline when seen in position. Metaplax thin, long and narrow.

We have not seen live or even preserved specimens of this species.

length	height	ratio h:l	
108.5 mm.	32.5 mm.	3.3	Sea Island, Georgia
95.0	31.0	3.1	Harbor Island Marsh, New Hanover County, North Carolina
70.0	22.0	3.2	10 miles south of Sabine, Texas
69.5	23.5	2.9	La Brea, Trinidad
63.5	19.5	3.2	Sénégal, Africa

*Types.* The location of the type of *Pholas campechiensis* Gmelin is unknown. Gmelin made only one reference and that was to Lister 1770, *Historiae Sive Synopsis Methodicae Conchyliorum et Tabularum*, Editio Altera, pl. 432, fig. 275. We here select this figure to represent the type. The type locality is the Gulf of Campeche, Mexico. The type of *Pholas oblongata* Say is apparently lost as it is not in the Academy of Natural Sciences, Philadelphia where most of Say's types are located. The type of *Pholas can-deana* d'Orbigny from Cuba is in the British Museum according to Gray 1854.

*Remarks.* *Pholas campechiensis* Gmelin is most closely related to *P. chiloensis* Molina of the Eastern Pacific. It differs from this species by having a smaller, more delicate shell and by having the sculpture extending over the posterior slope. In *P. chiloensis* the sculpture is usually reduced to growth lines only on the posterior slope. See also remarks under *P. chiloensis* Molina.

*Pholas campechiensis* Gmelin though apparently not a rare species is very seldom collected alive. All specimens studied were dead and most of them were beach worn. Only

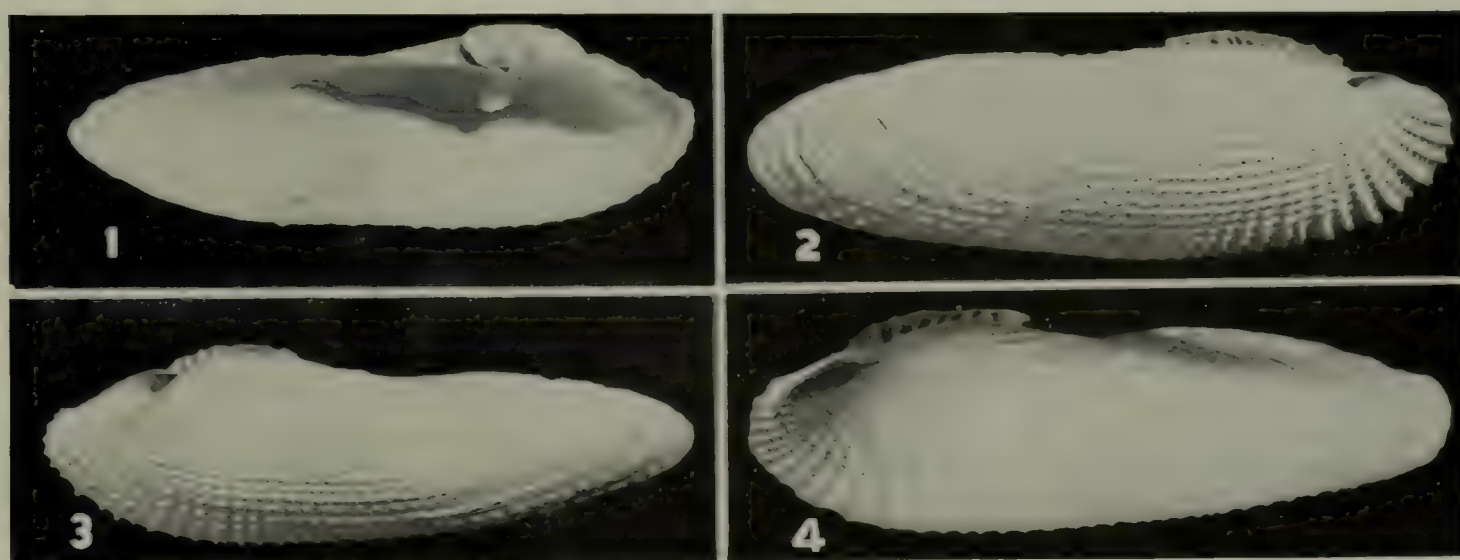


Plate 24. *Pholas campechiensis* Gmelin. Figs. 1-2. La Brea, Trinidad (about natural size). Fig. 1. Showing muscle scars, pallial sinus and spoon-shaped apophysis. Fig. 2. Showing the septate umbonal reflection and sculpture extending over the posterior slope. Fig. 3. Ten miles south of Sabine, Texas, a specimen with the sculpture becoming very weak on the posterior slope (about natural size). Fig. 4. Sénégal, Africa (about  $1\frac{1}{3}x$ ).

two specimens, both of them young, had the accessory plates. In certain areas these shells are common in the beach rubble as indicated by the large number of fragments found in a pint of drift material collected at High Island, Bolivar, Texas by T. E. Pulley. Fragments of the umbonal areas of at least one hundred specimens were in this small amount of drift. This portion of the shell is very strong: it is the last to be destroyed by wave action and consequently accumulates in the beach drift. It seems probable that *P. campechiensis* Gmelin, like *Panope bitruncata* Conrad, lives rather deep in the mud well below the low tide line, and, being deeply buried, the shells are not brought up by dredges. When the animals die the shells remain *in situ*, with the result that only a relatively few specimens are washed out and eventually reach shore.

A specimen received from A. S. Merrill was taken from a piece of waterlogged wood which had washed ashore at Folly Beach, South Carolina. In the same log there were several specimens of *Barnea truncata* Say, *Petricola pholadiformis* Lamarek, and *Marteisia cuneiformis* Say. We have a second piece of waterlogged wood that was taken at Daytona Beach, Florida and which also contained several specimens of this species. In both cases the specimens were young but quite normal and did not appear to be stunted or malformed.

From the material we have had for study the shells of *P. campechiensis* Gmelin appear to be far more uniform in shape and sculpture than are most species in this family. This would, perhaps, indicate a limited type of substratum in which this species can survive, probably stiff mud and sand.

*Range.* From North Carolina south through the West Indies to Sepetiba Bay, Rio de Janeiro, Brasil. EASTERN ATLANTIC: from Dakar, Sénégal south to Liberia.

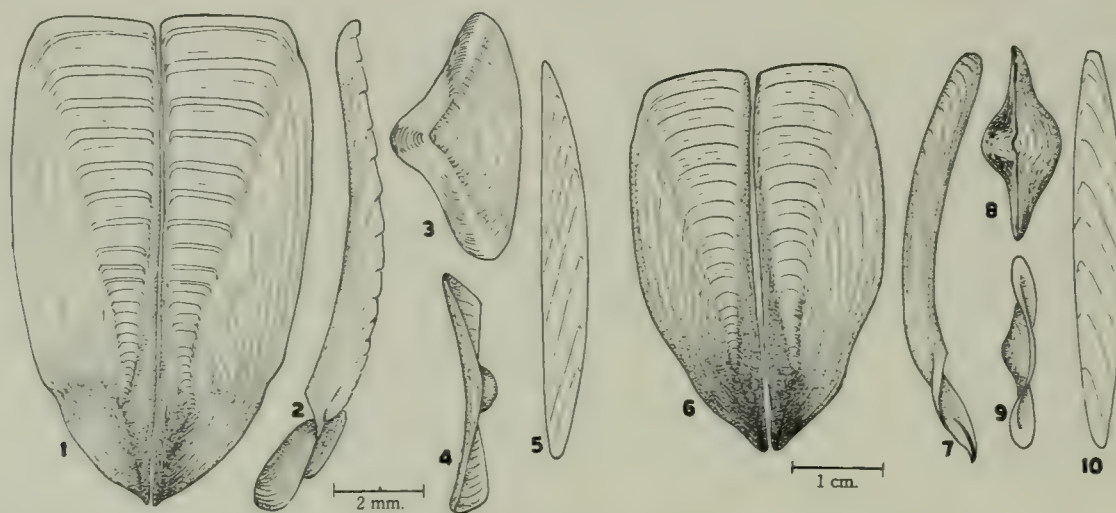


Plate 25. Dorsal plates of *Pholas* subgenus *Thorana*. Figs. 1-5. *Pholas* (*Thorana*) *campechiensis* Gmelin, Folly Beach, South Carolina. The plates of this very young specimen (31 mm. in length) are probably more highly sculptured than would be the case with older specimens. Fig. 1. Dorsal view of divided protoplax showing the nuclei located near the anterior central portion. Fig. 2. Side view of the right half of the protoplax from the outer edge showing the curvature. Fig. 3. Dorsal view of the mesoplax tipped forward to show the basal flange. Fig. 4. Dorsal view of the mesoplax in normal position (anterior to right). Fig. 5. Dorsal view of metaplax which is thin and almost entirely chitinous in young specimens. Figs. 6-10. *Pholas* (*Thorana*) *chiloensis* Molina, Chile. Fig. 6. Dorsal view of divided protoplax showing the nuclei located near the anterior central portion. Fig. 7. Side view of left half of the protoplax from the outer edge to show the curvature. Fig. 8. Dorsal view of the mesoplax tipped forward to show the basal flange. Fig. 9. Mesoplax in normal position (anterior to the right). Fig. 10. Dorsal view of the metaplax which is thin, fragile, and only partially impregnated with calcium.

*Specimens examined.* NORTH CAROLINA: Harbor Island Marsh, New Hanover Co. (MCZ). Ocracoke Island (ANSP). SOUTH CAROLINA: Myrtle Beach; Pawleys Island; Sullivans Island, Charleston (all Charleston Museum); Magnolia Beach (MCZ); Charleston (USNM); Folly Island (ANSP; A. Merrill). GEORGIA: Sea Island, Glynn Co. (MCZ; ANSP); St. Simon's Island (USNM). FLORIDA: Jacksonville Beach (MCZ); St. Augustine (Univ. of Michigan; ANSP; USNM); Daytona Beach (G. Quelch); Cape Canaveral (MCZ); Cape Sable (H. Moore); Sanibel Island (MCZ). LOUISIANA: Cameron (USNM). TEXAS: 10 miles southwest of Sabine (MCZ); Galveston (T. E. Pulley; ANSP); Port Aransas (MCZ); Mustang Island (J. Hedgepeth); Gulf Beach, Port Isabel (B. Weisenhaus); High Island (T. Pulley); Brownsville (USNM). GREATER ANTILLES: Jamaica (ANSP). LESSER ANTILLES: La Brea, Trinidad (MCZ); Moruga and Guayaguagare Beach, Trinidad (both H. J. Kugler). MEXICO: Tampico, Tamaulipas; Boquilla de Piedras; Tecolutla; Nautla and Vera Cruz, all in the State of Vera Cruz (all T. Pulley); Tuxpan and Barra de Alvarado, Vera Cruz (both M. E. Bourgeois). NICARAGUA: Wounta Haulover (MCZ). PANAMA: Colón (MCZ). COLOMBIA: Cartagena (MCZ). BRASIL: Ilha de Itaparica, Estado de Bahía (J. de Oliveira); Barra Seca, Espirito Santo (Thayer Expedition, MCZ); Aracaju, Estado de Sergipe; Parada Sahy, Sepetiba Bay, Estado Rio de Janeiro (both H. S. Lopes).

EASTERN ATLANTIC: SENEGAL: Dakar (Inst. Français d'Afrique Noire). GOLD COAST: Accra (MCZ). LIBERIA: Marshall (MCZ).

### ***Pholas (Thovana) chiloensis* Molina**

Plates 25, 26 and 27

*Pholas chiloensis* Molina 1782, Saggio Sulla Storia Naturale de Chili, p. 204 (Archipelago de Chiloe); King 1832, Zoological Journal **5**, p. 334; Hupé [in] Gay 1854, Historia de Chile, Zoologia **8**, p. 381, Atlas **2**, Mollusks, pl. 8, fig. 3.

*Pholas chiloensis* var. *parva* Sowerby 1834, Proceedings Zoological Society London, p. 69 (soft stone at 17 fathoms, Island of Plata, West Colombia [Ecuador], H. Cuming collector).

*Pholas laqueata* Sowerby 1849 [1850] Proceedings Zoological Society London, p. 161 [nude name]; Sowerby 1849, Thesaurus Conchyliorum **2**, pt. 10, p. 486, pl. 103, figs. 19–20 (Isle of Plata, Colombia [Ecuador], H. Cuming collector).

*Pholas (Dactylina) retifer* Mörch 1860, Malakozoologische Blätter **7**, p. 177 (Realejo, Nicaragua).

*Pholas dilecta* Pilsbry and Lowe 1932, Proceedings Academy Natural Sciences Philadelphia **84**, p. 88, pl. 11, figs. 8–9 (Corinto, Nicaragua).

*Distinctive characters.* Shell white, rounded at both ends, with septate umbonal reflections, with the sculpture greatly reduced or lacking on the posterior slope and with three accessory plates consisting of a divided protoplax, a mesoplax, and a metaplax.

*Description.* Shells rather large, reaching 123 mm. (about  $4\frac{7}{8}$  inches) in length and 44 mm. (about  $1\frac{3}{4}$  inches) in height, elliptical to oval in outline, rounded and gaping slightly at both ends, with double septate umbonal reflections, and generally lacking sculpture on the posterior slope. Color a dull chalky-white. Umbos prominent and located near the anterior fourth of the shell. Umbonal reflections free anterior to the umbos, but closely appressed, double and septate over the umbos. There are 14 to 16 septa in the average three to four inch specimen. Sculpture consisting of concentric ridges and radial ribs with imbrications produced where the two cross one another. The concentric ridges are very prominent and laminated on the anterior slope, much lower and weaker on the

disc, and generally evident only as growth lines on the posterior slope. The radial ribs are strong on the anterior slope, becoming much weaker on the disc and are completely lacking on the posterior slope. In most specimens there is a rather definite line of demarcation between the sculptured disc and the nearly smooth posterior slope. Interior of shell white and glazed, the external sculpture showing internally as a series of grooves. Muscle scars and pallial line well indicated. The pallial sinus is broad and deep, extending inward three fourths of the distance to the umbo. Apophyses rather heavy, slightly enlarged at the free end, and extending outward from under the umbo at a sharp angle posteriorly. Umbonal reflections usually worn down at the point of contact of the two valves. Proto-plax divided longitudinally into two parts. Each half is truncate posteriorly, acuminate anteriorly, has well marked growth lines and anterior nuclei which are located near the inner margin. Mesoplax transverse and nearly diamond-shape in outline. Metaplax long and narrow, exceedingly fragile and only slightly to moderately impregnated with calcium. Periostracum thin, light straw-yellow, and deciduous.

Siphons a pale brown in color (an old preserved specimen), separated slightly at their posterior extremity and with small uniform papillae covering the entire surface. Foot elliptical in outline, long and thin. Foot and mantle light-ivory in color.

length	height	ratio h:l	
122.5 mm.	39.0 mm.	3.1	Kino Bay, Sonora, Mexico
112.5	37.5	3.0	" " " "
114.5	45.5	2.5	Paracas, Peru
93.5	29.0	3.2	Panama City, Panama
90.0	30.0	3.0	Chiloe Island, Chile
75.0	22.0	3.4	Holotype, <i>P. dilecta</i> Pilsbry and Lowe
71.6	22.2	3.2	Cotype, <i>P. laqueata</i> Sowerby

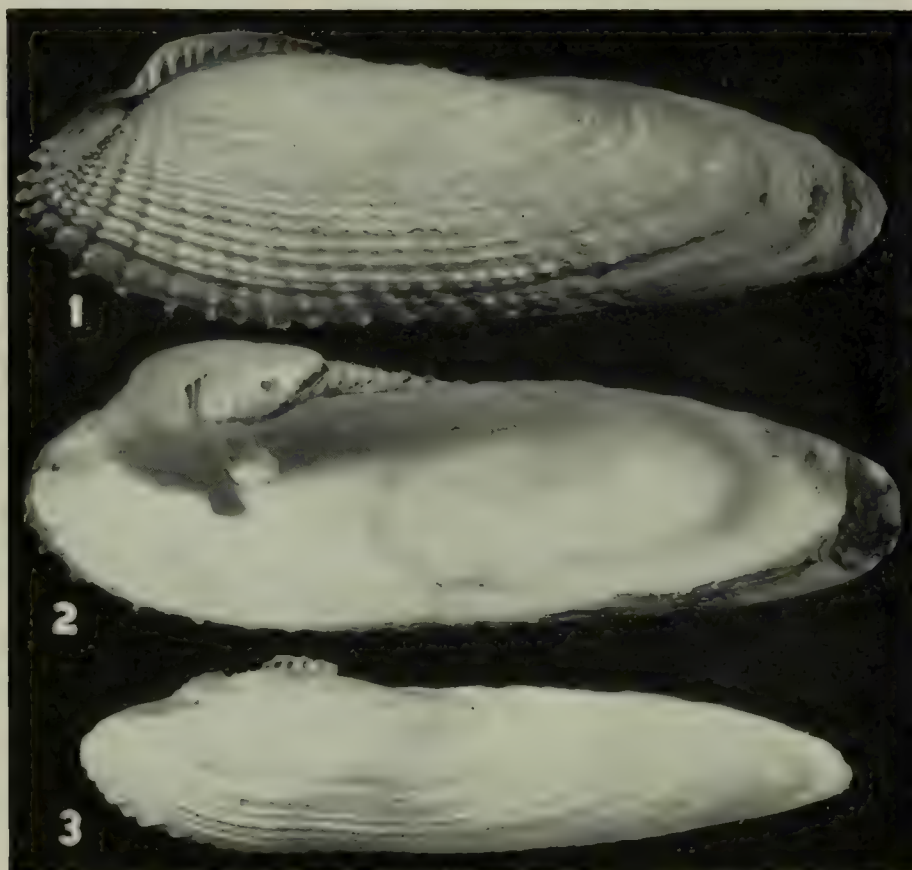


Plate 26. *Pholas chiloensis* Molina. Figs. 1-2. Chiloe Island, Chile. Fig. 3. Holotype of *Pholas dilecta* Pilsbry and Lowe (= *chiloensis* Molina) from Corinto, Nicaragua. This specimen was not photographed in the conventional position but was tipped forward in order to show the remains of the septate umbonal reflection, most of which had been broken off. In this position the shell appears to be narrower than it is (all natural size).

**Types.** The location of the type specimens of *Pholas chiloensis* Molina is unknown. We here select the figure given by Hupé in Gay 1854, *Historia de Chile, Zoologia* 8, p. 381, Atlas 2, pl. 8, fig. 3 to represent the type. The type locality is Chiloe Island, Chile. We figure a topotype. The type specimen of *P. chiloensis parva* Sowerby from the Island of Plata, Ecuador and *P. laqueata* Sowerby from the same locality are apparently lost. They are not in the Cuming collection in the British Museum according to a letter received from G. L. Wilkins. We have seen a probable cotype of the latter species, originally from the Cuming collection and now in the Zoologische Museum, Amsterdam. The whereabouts of the types of *Pholas retifer* Mörch is unknown. The holotype of *Pholas dilecta* Pilsbry and Lowe from Corinto, Nicaragua is in the Academy of Natural Sciences Philadelphia, no. 155299.

**Remarks.** *Pholas chiloensis* Molina is very closely related to *P. campechiensis* Gmelin of the Western Atlantic. Young specimens of the two are difficult or even impossible to distinguish. In older specimens, *P. chiloensis* Molina can be distinguished by its larger size, heavier shell, its generally higher umbonal reflection and its nearly smooth posterior slope.

There is a rather wide range of variation in the ratio of the length to the height of the valves in the species, the length of the shell ranging from two and one half to nearly three and one half times the height. Older specimens are usually higher and have much heavier umbonal reflections.

Through the kindness of Dr. H. A. Pilsbry we were able to study and figure the type of *Pholas dilecta* Pilsbry and Lowe. The holotype specimen appears to be only a rather young, beach-worn specimen of *P. chiloensis*. Specimens from Kino Bay, Sonora, Mexico labelled *P. dilecta* by Lowe are definitely this species.

Very little is known concerning this species beyond the fact that it has a rather wide



Plate 27. *Pholas chiloensis* Molina. Fig. 1. *Pholas laqueata* Sowerby (= *P. chiloensis* Molina) from west Colombia, Hugh Cuming collector, Cotype ( $1\frac{1}{2}x$ ). Fig. 2. Kino Bay, Sonora, Mexico. H. N. Lowe collector (natural size).

range of distribution, extending as it does from northern Mexico to Chiloe Island, Chile. Hupé stated that it was a rather common species on Chiloe Island, boring into soft stone. Captain Phillip King who was on the *HMS Adventure* and the *Beagle* when those ships were surveying the coast of South America stated "the soft parts of *Pholas chiloensis* are considered very delicate by the inhabitants of the Island of Chiloe, by whom the animal is called 'Co-mes.' They are found in great abundance at low water imbedded in the rocks near Sandy Point at San Carlos de Chiloe." Despite this apparent abundance in restricted localities the species is generally rare in collections. We have seen only one preserved specimen and most of the material studied was beach worn.

*Range.* From Kino Bay, Sonora, Mexico south to Chiloe Island, Chile.

*Specimens examined.* MEXICO: Kino Bay, Sonora (MCZ; ANSP); Laguna de Scammon, Baja California (ANSP); Santo Domingo, Baja California (USNM); Mazatlan, Sinaloa; Acapulco, Guerrero (both MCZ). NICARAGUA: Corinto (ANSP; W. J. Eyerdam). PANAMA: Panama City (MCZ; Univ. of Michigan); Pena Prieta, Panama City (USNM). ECUADOR: between Manglalaralto and Monte (USNM); Guayaquil (MCZ; Redpath Museum). PERU: North of Payta (USNM); Payta (USNM; ANSP); Paraca Bay (MCZ). CHILE: Chiloe Island (AMNH).

### Genus *Zirfaea* Gray

*Zirfaea* Gray 1840 [in] Synopsis of the Contents of the British Museum, ed. 42, p. 154 [nude name].

*Zirfaea* Gray 1842 [in] Synopsis of the Contents of the British Museum, ed. 44, p. 76 [defined, but no species listed].

*Thurlosia* 'Leach' Catlow and Reeve 1845, The Conchologist's Nomenclator, p. 3 (genotype, *Pholas crispata* Linné, monotypic).<sup>1</sup>

*Zirfaea* 'Leach' Gray 1847, Proceedings Zoological Society London, p. 188 (genotype, *Pholas crispata* Linné, monotypic).

*Zirphaea* Leach 1852, A Synopsis of the Mollusca of Great Britain, p. 252 (genotype, *Pholas crispata* Linné, monotypic).

Shell oval in outline, beaked anteriorly, rounded to truncate posteriorly, widely gaping at both ends and having a sulcus extending from the umbo to the ventral margin. There is a single accessory dorsal plate, the mesoplax, which is small and more or less triangular in outline. Apophyses solid, strongly curved, broadened and often spoon-shaped at the free end.

The genus *Zirfaea* is limited in its distribution to the colder waters of the Northern Hemisphere. *Zirfaea crispata* Linné is known from both sides of the Atlantic, while *Z. pilsbryi* Stearns is restricted, so far as known, to the Pacific coast of North America.

Genotype, *Pholas crispata* Linné, subsequent designation, Gray 1847.

<sup>1</sup> It is unfortunate that the name *Thurlosia* was introduced by Catlow and Reeve just two years before Gray set the type for *Zirfaea*. Should descriptions of genera with no species listed be invalidated in the future, the name *Thurlosia* Catlow and Reeve 1845 will replace *Zirfaea* Gray 1842, unless this later name be placed on the list of Nomina Conservanda.

**Zirfaea crispata Linné**

Plates 1, 3 and 28 to 30

*Mya crispata* Linné 1758, Systema Naturae, ed. 10, 1, p. 670 (O. septentrionali).*Pholas crispata* Linné 1776, Systema Naturae, ed. 12, 1, pt. 2, p. 111.*Pholas bifrons* da Costa 1778, Historia Naturalis Testaceorum Britanniae, p. 242, pl. 16, fig. 4 (Cornwall, Lincolnshire, Yorkshire, Wales, etc. [British Isles]).*Solen crispus* Gmelin 1790, Systema Naturae, ed. 13, 1, pt. 6, p. 3228 (Teers [Tees River] Angliae).*Pholas parvus* 'Pennant' Donovan 1800, The Natural History of British Shells 2, pl. 69 (non *Barnea parva* Pennant).*Pholas crispa* de Blainville 1825, Manuel de Malacologie, p. 578, pl. 79, fig. 7.*Zirfaea crispata* Linné, Gray 1847, Proceedings Zoological Society London, p. 188.*Zirfaea crispata* var. *truncata* Kaas 1939, Basteria 4, no. 1, p. 7, pl. 1 (Texel Island, Netherlands).

**Distinctive characters.** Shells white, beaked anteriorly, rounded to truncate posteriorly, gaping at both ends and having an umbonal-ventral sulcus. Mesoplax very small and triangular in outline. Valves usually in contact for only a short distance near the sulcus. Siphons smooth, without the minute chitinous spots found in the Eastern Pacific species.

**Description.** Shells reaching 93.2 mm. (about  $3\frac{3}{4}$  inches) in length and 49.2 mm. (about 2 inches) in height, beaked anteriorly, broadly rounded to truncate posteriorly, gaping at both ends and with an umbonal-ventral sulcus. Valves usually in contact only at the umbos and a small area on the ventral margin at the sulcus. In young specimens the umbonal-ventral sulcus is quite pronounced and is evident on the inside of the valve as a ridge. In older specimens the internal ridge is no longer visible, and the sulcus exists only

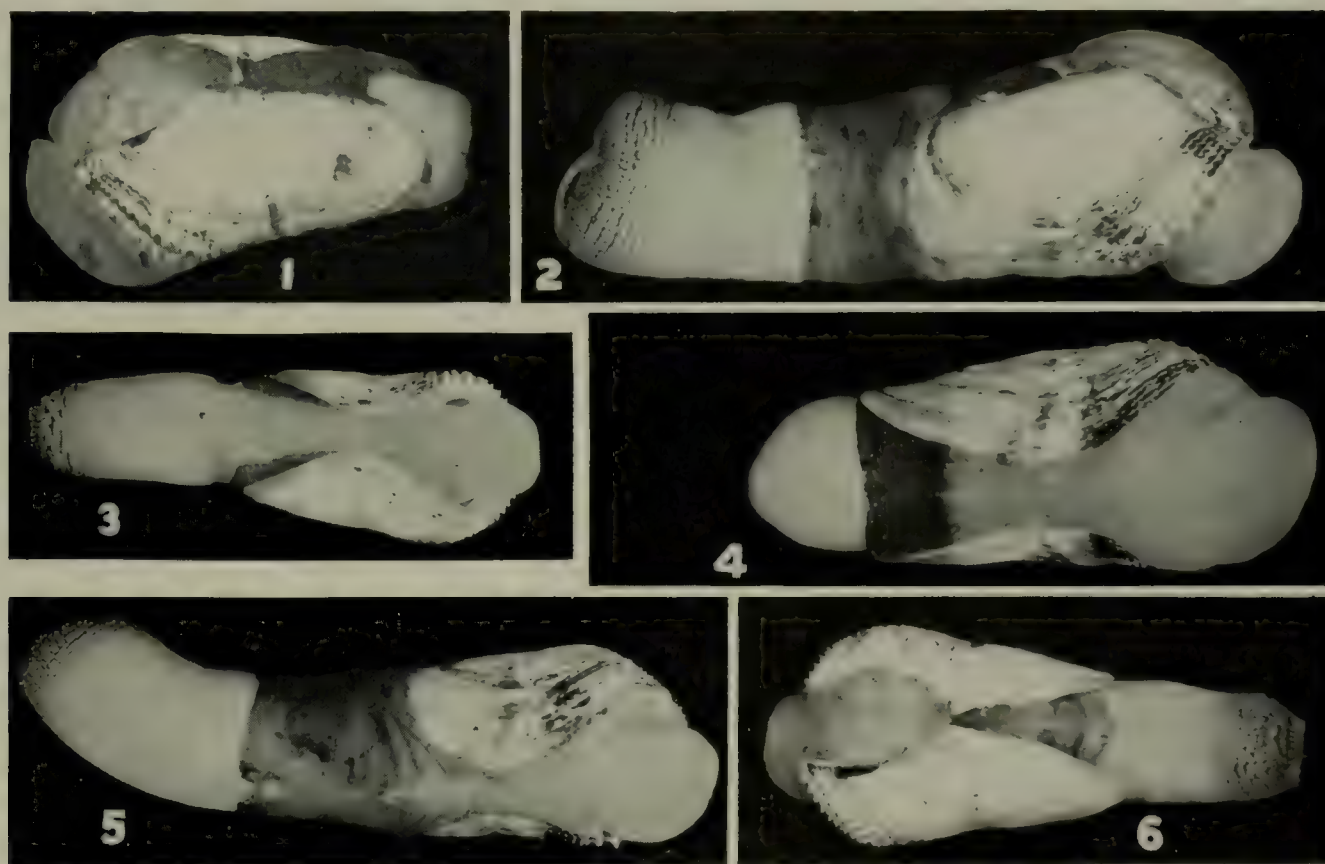


Plate 28. *Zirfaea crispata* Linné. Figs. 1-6. Rye Harbor, New Hampshire. Fig. 1. Shows the extent to which the animal can withdraw into the shell. Fig. 2. Side view to show the expanded foot. Figs. 3-4. Ventral views showing the way in which the animal can form various openings between the mantle and the foot, through which streams of water can be directed into the anterior end of the burrow (all natural size).

as a shallow furrow on the outside of the valve. In many young specimens this internal ridge is swollen at the ventral margin forming an incipient condyle. Color a dull chalky-white. Sculpture consisting of numerous concentric ridges which are laminated and strongly imbricated anterior to the sulcus but are evident only as growth ridges on the posterior slope. Radial ridges, expressed only by the radial arrangement on the rows of imbrications, are strong on the beaks, but are reduced in strength toward the umbos and posteriorly toward the sulcus. In older specimens these imbrications may be reduced to undulating ridges. Umbonal reflections broad and closely appressed over the umbos. Interior of shells white and lightly glazed in young specimens while in older specimens it is usually chalky. Muscle scars and pallial sinus well marked, particularly in older specimens. Pallial sinus broad and deep, and extending anteriorly about three fourths the distance to the umbos. Apophyses solid, strongly curved, broadening at the free edge and becoming quite spoon-shaped in some specimens. Protoplax lacking. Mesoplax small, fragile, triangular in outline, and with a small basal flange. Periostracum thin, light straw-yellow and deciduous.

The siphons are united and may be extended six to eight times the length of the shell. The anterior one half to two thirds of the siphons are covered with a sheath of light straw-yellow to medium-brown periostracum. The remainder of the siphons lack the periostracum and are white in color. The posterior ends of the siphons are marked with very fine reticulations of dark mahogany-red. When the animal is extended, the reticulations are widely spaced giving this region a gray-pink color. Incurrent siphon with dark red, papillose and ciliated ridges running well into the siphonal tube. These ridges terminate in branched cirri at the aperture. Excurrent siphon devoid of the internal ridges.

length	height	ratio h:l	
93.5 mm.	49.2 mm.	1.9	Small Point Beach, Maine
81.5	47.0	1.7	Nahant, Massachusetts
70.0	42.5	1.6	Vaagnas Cape, Tromsø, Norway
45.0	28.0	1.5	Dover, England
34.0	14.0	2.4	Scituate, Massachusetts
30.0	23.0	1.3	Portland, Maine
29.5	21.0	1.4	Paratype of <i>Z. c.</i> var. <i>truncata</i>

*Types.* According to Hanley (1855, *Ipsa Linnaei Conchylia*, p. 26), the type of *Mya crispata* Linné is in the Linnean collection. The type locality given by Linné was "O. septentrionali." It is here restricted to the banks of the Tees River, Middlesbrough, England. This is the locality given by Lister 1678, the only publication to which Linné referred for this species. The location of the types of *Pholas bifrons* da Costa is unknown. The holotype of *Zirfaea crispata* var. *truncata* Kaas is in the collection of Dr. J. Th. Henrard of Oegstgeest, Netherlands. Paratypes are in the collection of Dr. Piet Kaas and the Museum of Comparative Zoölogy, no. 193521. The type locality is Isle of Texel, Netherlands. We are grateful to Dr. Kaas for sending us a paratype specimen.

*Remarks.* *Zirfaea crispata* Linné is close in its relationship to *Z. pilsbryi* Lowe of the Eastern Pacific. However, it may be distinguished from that species by its smaller size, lighter, more fragile shell, less inflated posterior region, and by its smooth siphons which are devoid of the minute chitinous spots usually found in Eastern Pacific species. In addition, the valves of *Z. crispata* Linné are usually in contact for only a short distance on

the ventral margin near the umbonal-ventral sulcus. The young specimens of these two species are difficult and often impossible to distinguish. See remarks under *Z. pilsbryi* Lowe.

The shells of *Z. crispata* Linné are variable in size and weight depending upon the conditions under which the animals are living. Specimens living in soft, easily worked salt marsh peat are elongate-oval in outline, and have rather widely spaced imbricated ridges and fragile shells, indicating rapid growth. Those boring into rock or hard wood are stunted, truncate, and have closely packed, badly worn imbricated ridges and heavy shells, indicating hard work on the substratum and slow growth. It was such specimens that were named *Z. crispata truncata* Kaas. Though this species is usually found in salt marsh peat deposits, specimens have been found in a wide variety of material ranging from stiff mud and blue clay to waterlogged wood, hard pine, poor quality bricks and red sandstone. They are probably most abundant in the lower intertidal zone, but have been taken alive in depths as great as 40 fathoms. They can withstand exposure to temperatures ranging from below freezing to 26.6° C. However, as they live in the lower intertidal zone or below the low tide level they are never exposed to the extremes of temperature for an extended period of time. In laboratory experiments they can withstand a rather wide range of salinity, but they are limited in nature to a marine habitat. Their distribution is spotty though they may be exceedingly abundant in any one locality where proper conditions exist. In one bed we counted over fifty specimens in a square foot of peat. Many of the specimens were stenomorphs as their burrows were too close to allow complete growth. The burrows were vertical and many extended to a depth of six inches or more.

*Zirfaea crispata* Linné seldom bores into wood unless it is completely waterlogged and softened. However, in a test block submerged at Beverly, Massachusetts, we found 56 minute specimens of this species. Among the thousands of test blocks that have been examined from New England, this is only the second record for *Zirfaea* in the tests at the Clapp Laboratories.

Little is known of the life history of this species, but according to Dr. C. M. Sullivan (1948) the larvae occur in the plankton at Malpeque Bay, Prince Edward Island, from the middle of June to the middle of July, and at that time the temperature of the water ranges from 15° to 22° C. See also the introduction for further notes and figures of the young.

**Range.** EASTERN ATLANTIC: from Tromsø, Norway south to Boulogne, France. WESTERN ATLANTIC: from Labrador south to Anglesea, New Jersey. The record given by C. W. Johnson, 1934 for South Carolina appears to be in error.

**Specimens examined.** EASTERN ATLANTIC: NORWAY: Vaagnas Cape, Tromsø Sound (Trondheim Museum); Tromsø (W. J. Eyerdam); Lofoten (USNM). BRITISH ISLES: Oban (MCZ); South Rock, St. Andrews, Fife (Gatty Marine Laboratory); Liverpool (MCZ; AMNH); Hilbre Point, Dee River (Charleston Museum); Dover; Scarborough (both MCZ). NETHERLANDS: Isle of Vlieland (A. N. C. ten Broek); Isle of Texel; Was-senaar, about 6 miles north of The Hague (both P. Kaas); Scheveningen, The Hague (D. Smits). BELGIUM: Nieuport (W. J. Eyerdam). FRANCE: Boulogne (MCZ).

WESTERN ATLANTIC: LABRADOR: (Redpath Museum). NEWFOUNDLAND: (USNM). QUEBEC: Gaspé (Redpath Museum); Coffin Island, Magdalen Islands (MCZ). PRINCE EDWARD ISLAND: Malpeque Bay (J. C. Medcof); Governor's Island (Redpath Museum). CAPE BRETON ISLAND: (USNM). NOVA SCOTIA: Straits of Northumberland (G. H. Cox); Halifax (Redpath Museum); Digby (J. Bradley); off Digby in 40 fathoms (J. Magarvey); Sable Island (USNM). MAINE: Small Point Beach (A. Clarke); Penobscot Bay (MCZ); Casco Bay (MCZ; Charleston Museum); Schoodic Point, Winter Harbor (G. Moore); Portland; Kennebunk Beach (both MCZ); Skillings River, Lamoine (J. Rankin); Jewels Island, Casco Bay; Isle of Shoals; John's Bay, Bristol; Broad Sound (all USNM). NEW HAMPSHIRE: Rye Harbor (G. Moore). MASSACHUSETTS: Plum Island, Newburyport; Ipswich; Salem; Beverly; Lynn; Swampscott; Nahant (all MCZ); Salisbury (A. Clarke); Chelsea (AMNH); Winthrop; Scituate; Manomet Point; North Beach, Orleans; Monomoy, Chatham (all MCZ); Hull; Duxbury (both MCZ; USNM). RHODE ISLAND: Newport (ANSP). NEW YORK: Sag Harbor, Long Island (USNM); Noyack Bay, Long Island (R. Latham). NEW JERSEY: Sandy Hook (AMNH); Asbury Park; Point Pleasant, Atlantic City; Ocean City; Anglesea (all ANSP).

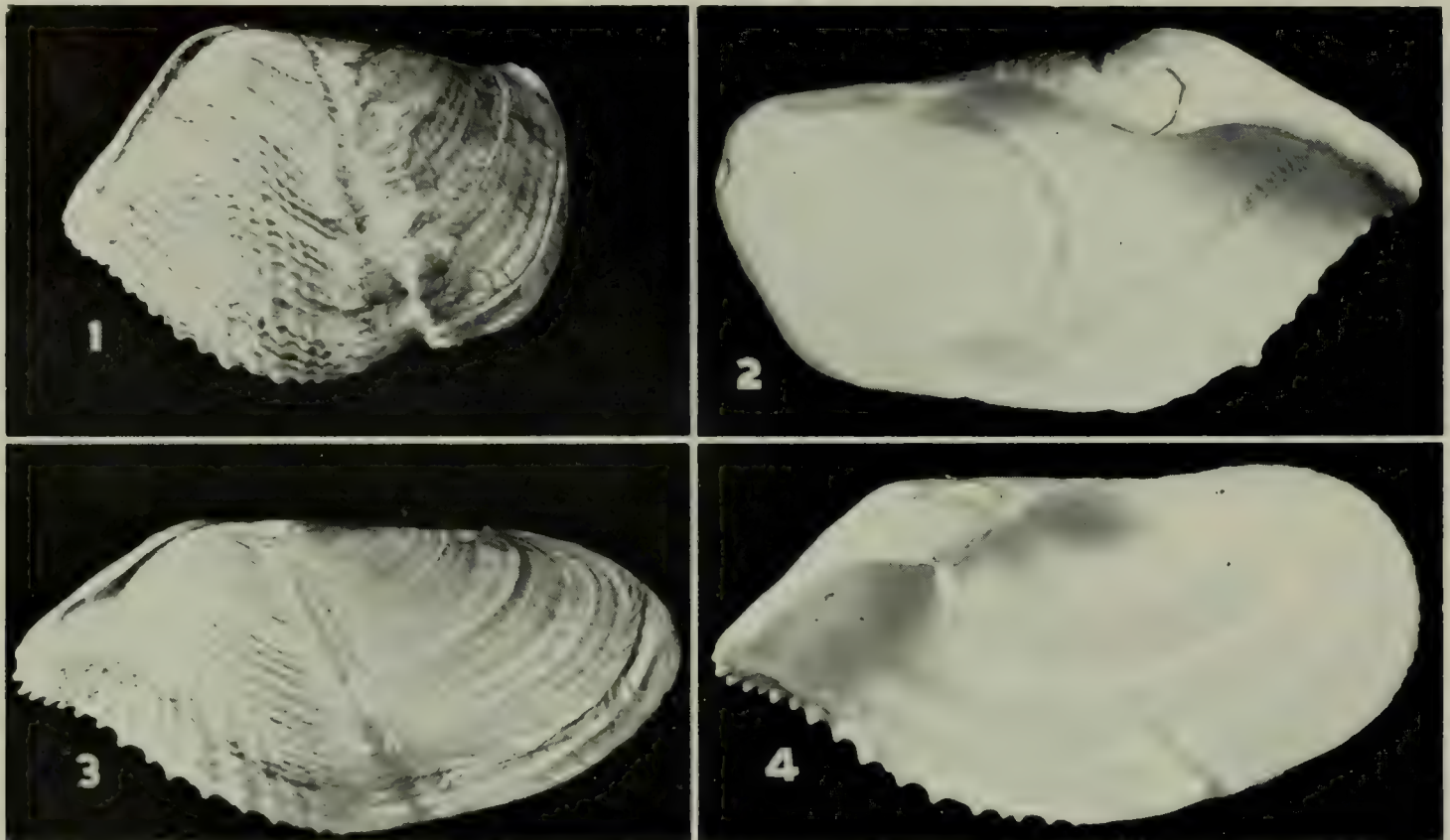


Plate 29. *Zirfaea crispata* Linné. Fig. 1. Paratype of *Zirfaea crispata* var. *truncata* Kaas (= *Zirfaea crispata* Linné). Isle of Texel, Netherlands ( $1\frac{1}{2}x$ ). Fig. 2. Nahant, Massachusetts. An old specimen to show palial line and muscle scars (apophysis broken off) (natural size). Figs. 3-4. Rivermere, Scituate, Massachusetts. Fig. 4. A young specimen to show the internal umbonal-ventral ridge which more or less disappears in the adult ( $1\frac{1}{2}x$ ).

### *Zirfaea pilsbryi* Lowe

Plates 30 to 34

*Zirfaea gabbi* of authors, not of Tryon.

*Zirfaea pilsbryi* Lowe 1931, *Nautilus* 45, p. 53, pl. 3, figs. 1-2 (Bollinas, California).

*Distinctive characters.* Shell beaked anteriorly, broadly rounded to truncate posteriorly, gaping at both ends, and having a sulcus extending from the umbo to the ventral mar-

gin. Mesoplax small and more or less triangular in outline. Valves usually in contact on the ventral margin for most of their length posterior to the sulcus. Siphons usually with minute chitinous spots.

*Description.* Shell reaching 122 mm. (about  $4\frac{3}{4}$  inches) in length and 68 mm. (about  $2\frac{1}{2}$  inches) in height, beaked anteriorly, broadly rounded to truncate posteriorly and widely gaping at both ends. Valves in contact with each other at the umbos and for most of the ventral margin posterior to the pedal gape. Sulcus extending from the umbo obliquely to the ventral margin. In young specimens this sulcus may be barely visible externally but it is clearly indicated internally as a strong beaded rib. In adult specimens the furrow is always distinct externally but may be indicated on the inside of the valve only as a row of isolated beads or it may be completely lacking. Umbonal reflection broad and appressed against the umbo. At the point of contact of the two valves the reflection is always worn away, even in young specimens, as this area acts as an incipient condyle on which the valves rotate. Color a dull chalky-white to light-salmon. Sculpture consisting of numerous concentric ridges which are laminated and strongly imbricated on the anterior slope but are indicated only as growth lines posterior to the furrow. The radial ribs are restricted to the anterior slope and are indicated only by the radial arrangement of the imbrications which are produced where the concentric ridges and radial ribs cross. In young specimens the imbrications are very strong on the ventral margin of the anterior slope, reducing in strength toward the umbo and posteriorly toward the furrow. In old though living specimens, the sculpture on the anterior slope may be reduced to undulating ridges, the free edges of which are recurved, giving an appearance of thick-

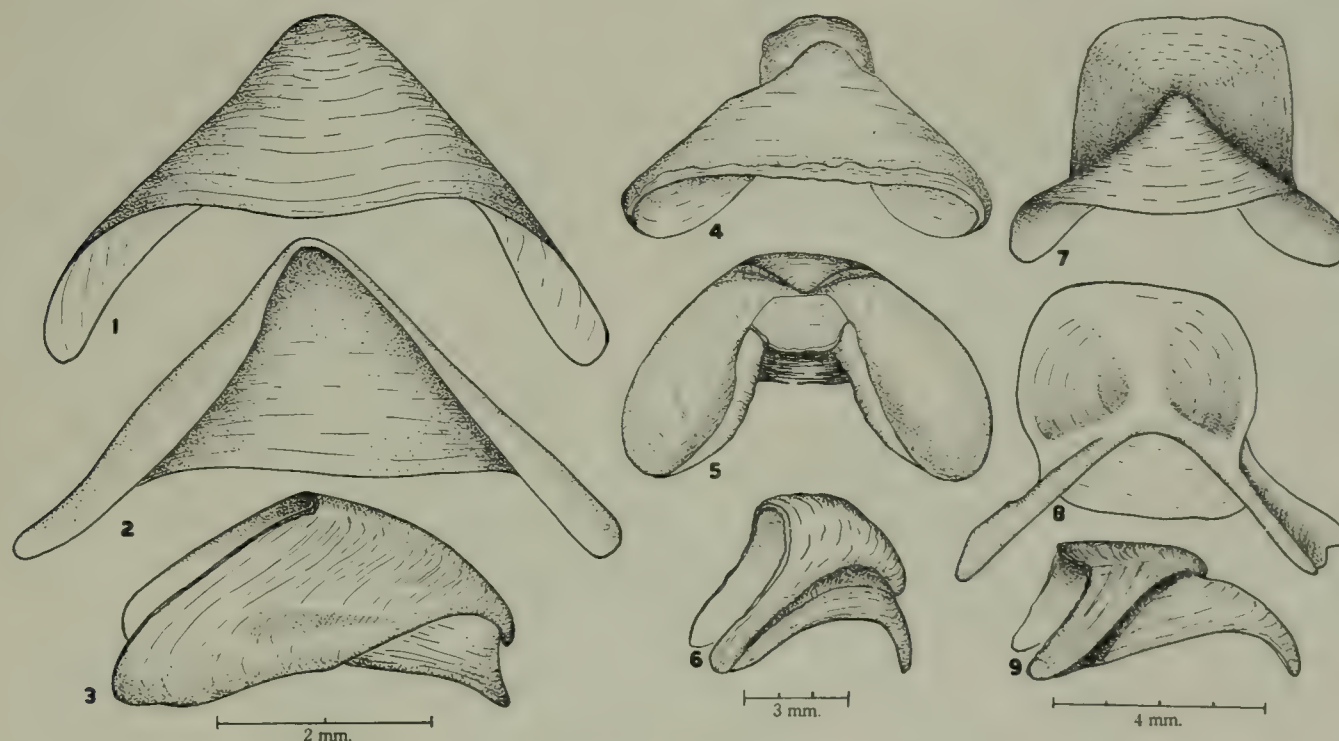


Plate 30. Mesoplax of *Zirfaea*. Figs. 1-3. *Zirfaea crispata* Linné, Rye Harbor, New Hampshire. Fig. 1. Dorsal view. Fig. 2. Ventral view. Fig. 3. Side view showing the basal flange which is generally not visible in either of the other views. Figs. 4-6. *Zirfaea pilsbryi* Lowe, Anaheim Bay, California, an old specimen. Fig. 4. Dorsal view showing the proportionately small basal flange typical of old specimens. Fig. 5. Ventral view. Fig. 6. Side view showing the marked curvature of the basal flange. Figs. 7-9. *Zirfaea pilsbryi* Lowe, Playa del Rey, California, a young specimen with a proportionately large basal flange typical of young and fast growing specimens.

ness. Interior of shell white to light-salmon in color and glazed. Muscle scars and pallial sinus well marked. Pallial sinus broad and deep extending inward nearly to the umbo. Apophyses rather large, solid, strongly curved, moderately to strongly spooned at the ventral margin and marked with concentric growth lines. Protoplax lacking. Mesoplax transverse, small but strong, more or less triangular in outline and usually with a well developed basal flange. Periostracum thin, straw-yellow to red-brown in color, and usually persistent on the posterior slope.

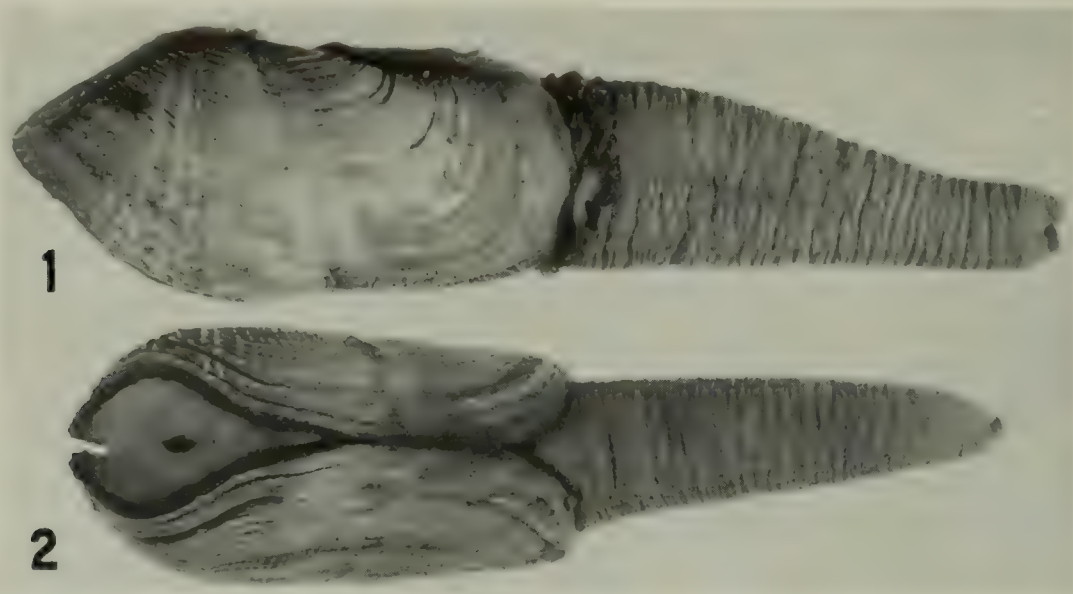


Plate 31. *Zirfaea pilsbryi* Lowe, Alamitos Bay, California (about  $\frac{5}{8}$  natural size). Showing the minute chitinous spots on the siphons and the extent to which the valves are in contact on the ventral margin.

(Photographs received through the kindness of J. E. Fitch, California Fisheries Laboratory.)

The siphons are united and they may be extended six to eight times the length of the shell. The anterior one third of the siphons is covered with a dark-horn to red-brown periostracum which also extends over the posterior end of the shell. The remainder of the siphons lacking periostracum, a gray-white to light-ivory in color, and usually irregularly marked with small orange chitinous spots. These spots vary from one half to two millimeters in greatest diameter and never reach the size or thickness of those found on the siphons of *ovoidea* Gould. The area immediately surrounding the siphonal openings is marked with fine reticulations of dark mahogany-red. Incurrent siphon with dark-red, branched cirri at the opening, and these are continued as ridges which extend a short distance within. Excurrent siphon with several minute ridges and small cirri. Foot nearly circular in outline and truncate. Foot and mantle light-ivory in color. The above description of the soft parts is based upon preserved material.

length	height	ratio h:l	
122.0 mm.	67.0 mm.	1.8	Newport, Oregon
115.5	55.2	2.1	Anaheim Bay, California
105.0	68.0	1.5	South Alki Beach, Seattle, Washington
99.5	51.0	1.9	Lisabeula, Washington
76.0	37.0	2.0	Holotype. Bolinas, California
61.5	34.5	1.8	San Diego, California

*Types.* The holotype of *Zirfaea pilsbryi* Lowe is in the Academy of Natural Sciences, Philadelphia, no. 50809, from Bolinas, California, H. Hemphill, collector. Paratypes are in the Lowe Collection which is now at the San Diego Museum of Natural History.

*Remarks.* *Zirfaea pilsbryi* Lowe is closely related to *Z. crispata*, but may be distinguished from that species by its larger size and by having the ventral margin of the valves, especially in older specimens, nearly straight posterior to the pedal gape. This allows the valves to come in contact for a considerable distance along the ventral margin as shown in the figure of the living specimen. In *Z. crispata* the ventral margin is usually in contact for only a very short distance near the base of the umbonal-ventral sulcus. The post-umbonal area of *Z. pilsbryi* is generally longer, more truncate and inflated than in *Z. crispata* Linné, and in addition, the siphons are usually marked with small chitinous spots.

A lot of *Zirfaea* received from Humboldt Bay, California, lacks the small chitinous discs on the siphons, and in other respects these specimens more closely resembled *Z. crispata* of the Western Atlantic. In a letter, J. E. Fitch of the California Fisheries Laboratory informed us that the east coast oyster has been imported at this locality and he stated that there are now in the bay large beds of *Mya* and *Venus* and a number of gastropods all of which came in with the seed oysters of *Crassostrea*. Consequently it may well be that both species of *Zirfaea* now occur at this locality.

*Zirfaea pilsbryi* Lowe was formerly known as *Z. gabbi* Tryon. Lowe examined the type of *gabbi* and found that it was not in the genus *Zirfaea*, but was the young stage of a *Penitella*, so he placed it in the synonymy of *Penitella penita* Conrad. For a further discussion of this species see the remarks under *Penitella penita* Conrad and *P. gabbi* Tryon which will be covered in Part II of this family.

*Zirfaea pilsbryi* Lowe is usually found boring into mud and clay banks, the larger specimens burrowing to a depth of ten to fourteen inches (Fitch 1953, p. 95). Occasionally, like its Western Atlantic counterpart, it is found boring into decaying, waterlogged wood.<sup>1</sup> Specimens from the Queen Charlotte Islands which had been boring into sand-

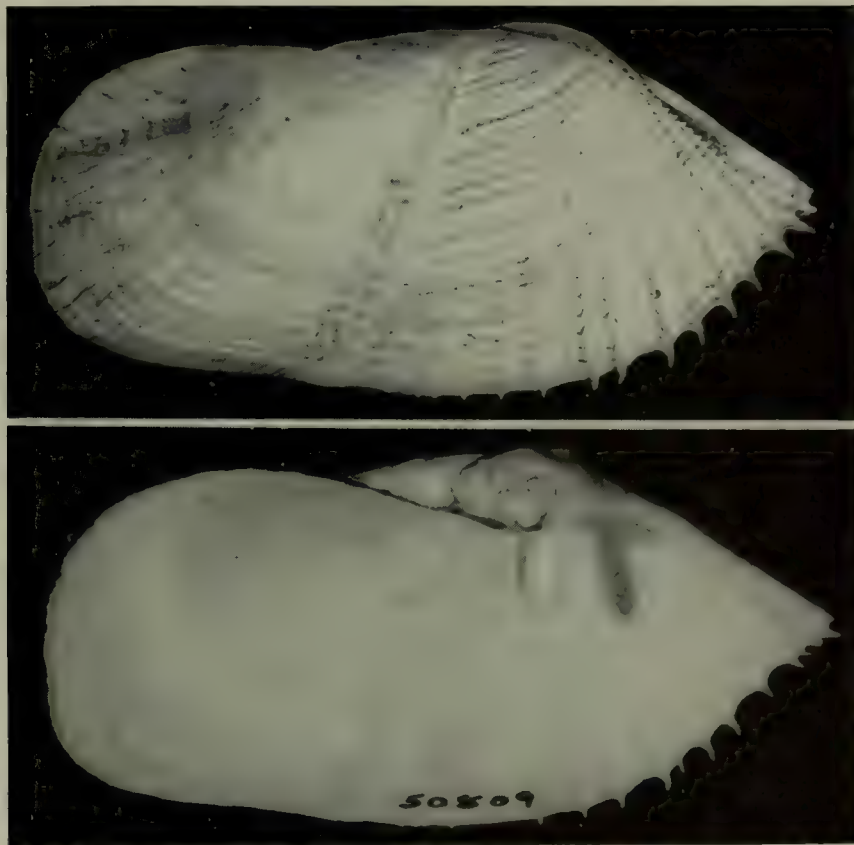


Plate 32. *Zirfaea pilsbryi* Lowe, from Bolinas, California. Holotype (slightly enlarged).

<sup>1</sup> W. K. Emerson 1951, Bulletin Southern California Academy of Sciences 50, pt. 2, p. 89-91.

stone were stunted and misshapen. An interesting account of the ecology and method of boring of this species is given by MacGinitie (1935, pp. 731-735).

*Range.* From Nunivak Island, Alaska south to San Jaunico Bay, Baja California (Fitch 1953, p. 95).

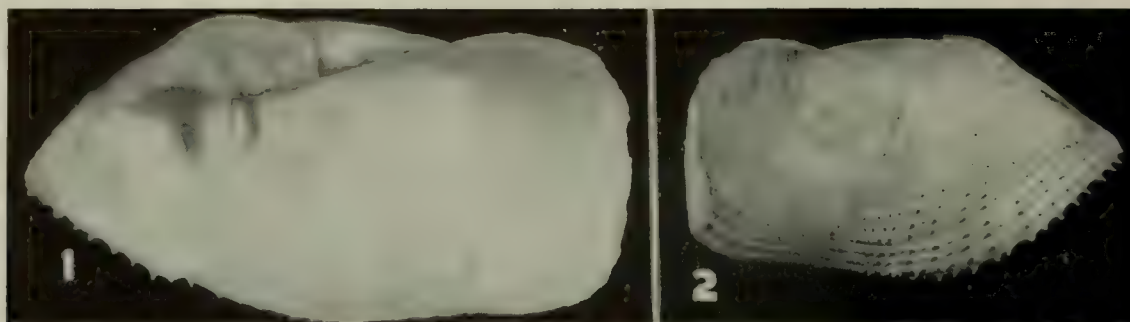


Plate 33. *Zirfaea pilsbryi* Lowe. Fig. 1. Bolinas, California. To show muscle scars and pallial line, umbonal-ventral ridge barely visible. Fig. 2. A truncate form from San Diego, California (both about  $\frac{3}{4}$  natural size).

*Specimens examined.* ALASKA: Nunivak Island; Port Möller; Bering Island (all USNM); Cordova (W. J. Eyerdam). BRITISH COLUMBIA: Queen Charlotte Islands (USNM). WASHINGTON: Port Orchard; South Alki Beach, Seattle; Anacortes; Brainbridge, near Winslow, Kitsap County (all W. J. Eyerdam); Fort Lawton Beach, Puget Sound; Lisabeula (both MCZ); Willapa Bay (E. P. Chace). OREGON: Netarts Bay, Tillamook County (R. Coats); Newport (ANSP). CALIFORNIA: Daby Island and Buhne Point, Humboldt Bay (both J. E. Fitch); Bolinas (MCZ; ANSP; USNM); San Francisco: Santa Cruz (both MCZ); Monterey Bay (E. P. Chace); Elkhorn Slough, Monterey Bay (J. E. Fitch); San Pedro Bay (AMNH); Anaheim Bay (E. P. Chace; USNM; MCZ); San Diego (AMNH; USNM); Playa del Ray (W. J. Eyerdam); Alamitos Bay, Long Beach (J. E. Fitch). MEXICO: Bahía San Quintín and Punta Abreojos, Baja California [dead and worn specimens] (both USNM).



Plate 34. *Zirfaea pilsbryi* Lowe, Marin County, California. Ventral view of opposed valves to show the apophyses and hinge area (about  $1\frac{1}{4}$ x).

## Notes

### *Barnea subtruncata* Sowerby

Two additional Mexican records for this species were received from Dr. S. S. Berry after the section on this species had been printed. These are San Felipe and Punta Cyote, northwest of La Paz, both Baja California in the Gulf of California.

### *Barnea maritima* 'd'Orbigny' Dall

*Barnea maritima* 'd'Orbigny' Dall 1889, Bulletin United States National Museum, no. 37, p. 72 (Texas) [nomen nudum].

We have been unable to find a description of this species by d'Orbigny and believe that it was possibly a manuscript name on specimens in the collection of the United States National Museum which Dall had used at the time he worked up his list of the marine mollusks of the southeastern states. Since that time this name has appeared in several lists.

\* \* \* \*

## Book Reviews

Abbott, R. T. 1954: American Sea Shells. D. Van Nostrand Co., Inc., New York, pp. 14+541, 40 plates (24 in color), 100 text figures. Abbott has presented the many students and collectors of our American marine mollusks with a very readable and informative book. He considers the shells of our east coast from Labrador to Texas, including only those West Indian elements that reach Florida, and the west coast from Alaska to southern California. For the professional worker it presents a source of information and answers many queries which arise almost daily. To the beginner and the "professional amateur" it will be helpful in determining their local material as well as giving suggestions on procedure in caring for the collection. Few, if any, of our common species have been overlooked and many of the rarer species have been included. The colored plates are excellent and the black and white plates are, for the most part, exceedingly clear as to detail. Many of the text figures are by J. C. McConnell who was for many years associated with Dall. Few artists have had his ability in pen drawing.

There is much in addition to the taxonomy and descriptive elements in this book. Abbott has included in detail, methods of collecting, life histories, habitats and many other subjects not presented in popular books on mollusks. Chapter 14 is a guide to the literature which is most valuable for locating additional information about our marine mollusks.

The scientific names of our mollusks change with the acquisition of new knowledge. Many new names or new name combinations appear in this book with no explanation for these various changes. This is unfortunate. These must either be accepted blindly or considered individually and restudied, a long and thankless task and a great duplication of effort. However, this criticism is trivial, considering the book as a whole. It is very well done and will do much to advance knowledge among an ever increasing number of competent students.—W. J. CLENCH

La Rocque, Aurèle 1953, Catalogue of the Recent Mollusca of Canada. National Museum of Canada, Ottawa, Bulletin no. 129, 9—406. This is an exceedingly important piece of research. The catalogue proper is arranged taxonomically from Classes down to Subgenera. Each species has the original citation and one or more references to standard North American monographs or other studies covering the species in question. Type localities are given as well as the known range for each species. The ranges for the marine mollusks of both coasts are now pretty well known, as well as for most species of land shells. The fresh-water species, however, are far less known and many of the ranges given by La Rocque are open to question. This is not at all the fault of La Rocque, but it is because the available literature on our fresh-water mollusks is mainly old, particularly papers of monographic scope, and many of the published data are quite unreliable. The author has a peculiar and somewhat misleading procedure which is to cite a species under its present genus followed by the original reference without the original name combination. For example:

“*Paravitrea multidentata* Binney 1840, Journal Boston Soc. Nat. Hist., vol. 3, p. 425.”

The genus *Paravitrea* was established by Pilsbry in 1898, a name, of course, unknown to Binney in 1840. Such entries are readily recognized in the present paper as La Rocque has dated the establishment of each genus. The danger here is that subsequent authors, not having a large library to consult, are very apt to quote as original from La Rocque such name combinations which were not given in the original citation.

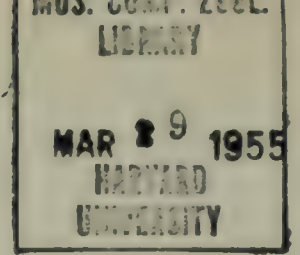
There is an excellent bibliography and a complete alphabetic index.—W. J. CLENCH

\* \* \* \*

Carcelles, Alberto R. 1953, Catalogo de la Malacofauna Antartica Argentina. Anales del Museo Nahuel Huapi 3, pp. 150—250, 5 plates and 1 map. This is a companion report to the three earlier papers on the mollusk fauna of Argentina by Carcelles which were reported upon in Johnsonia 2, p. 380. This present report covers the Antarctic fauna and lists 338 species included in 175 genera. As in previous reports, the author has given a brief history of the work accomplished in this area. The catalogue is arranged systematically, and for each species there are several references, the known range of the species and the localities for the specimens which he examined. An excellent table is given showing the geographic distribution of the species of this region and their occurrence as well in the Magellanic Province. The plates are excellent and 114 species have been illustrated. This very important piece of work when combined with Carcelles' three other papers, gives a complete summation of the Argentinian marine mollusks. There is also an extensive bibliography.—R. D. TURNER

# JOHNSONIA

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PHOLADIDAE

VOL. 3, NO. 34

## THE FAMILY PHOLADIDAE IN THE WESTERN ATLANTIC AND THE EASTERN PACIFIC

### PART II — MARTESIINAE, JOUANNETIINAE AND XYLOPHAGINAE

BY  
RUTH D. TURNER<sup>1</sup>

In the introduction to Part I of this study there is a general discussion of the classification of the Family Pholadidae and the various subfamilies of which it is composed. Also included in the first part are general data regarding life histories, ecology, distribution, methods of boring, anatomy, physiology and economic importance.

Since the publication of Part I, Dr. N. T. Mattox of the Allan Hancock Foundation has kindly sent all of their material for study. Most of the records have been incorporated

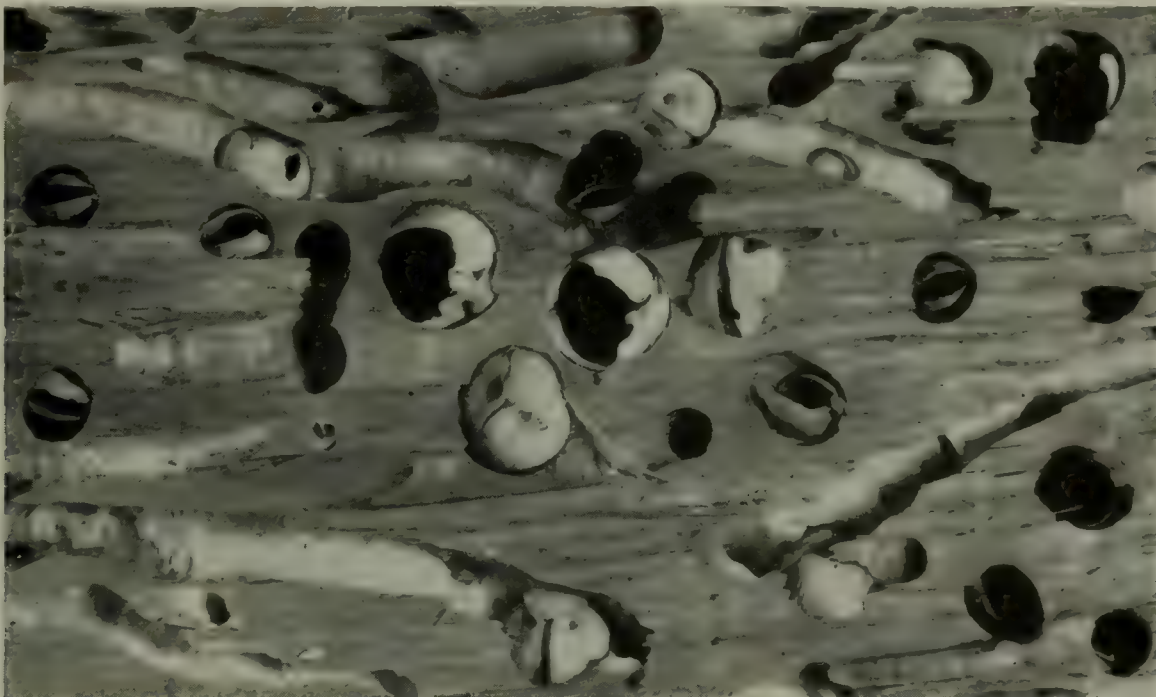


Plate 35. Damage caused by *Martesia striata* Linné and Teredinidae. Section of a test board which was submerged at San Juan, Puerto Rico on Sept. 21, 1944 and removed on March 21, 1945. The long tubes are the work of teredo or shipworms. Views of the anterior ends of specimens of *Martesia striata* Linné with the callum fully developed show the funnel-shaped pits formed by the umbonal reflections. Note that *Martesia* does not avoid the teredo tubes ( $1\frac{1}{3}x$ ).

<sup>1</sup>The family Pholadidae, Parts I-II, were submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, Dept. of Biology, Harvard University.

in the main portion of this paper. Records for the species covered in Part I will be included in a report for the Allan Hancock Foundation. A key to the genera of the Pholadidae is included at the end of the paper.

### Subfamily MARTESIINAE

### Genus *Chaceia*, new genus<sup>1</sup>

Shells moderate to large in size, gaping widely at both ends in the young stage and only partially closing the pedal gape with a callum in the adult stage. Shell divided into two parts by a pronounced umbonal-ventral sulcus. Valves, when in normal position, usually in contact for only a short distance on the ventral margin near the base of the umbonal-ventral sulcus. Protoplax lacking, being replaced by a dorsal extension of the callum. Mesoplax small, transverse, in one piece and similar to that found in *Zirfaea*. Metaplax and hypoplax lacking. Siphons large, incapable of retraction within the shell. Foot in young specimens broadly oval in outline and truncate, atrophied in the adult.

The genus *Chaceia* differs from other closely related genera in this subfamily by having the shell gaping at both ends, by lacking a siphonoplax and by having only a partial callum.

There is only one known species in this genus and this is limited in its distribution to California and Mexico.

Genotype, *Pholas ovoidea* Gould

### *Chaceia ovoidea* Gould

Plates 36-39

*Pholas ovoidea* Gould 1851, Proceedings Boston Society Natural History 4, p. 87; Gould 1853, Boston Journal of Natural History 6, p. 388, pl. 15, fig. 1 (Monterey, California).

*Pholadidea ovoidea* Gould, Gould and Carpenter 1856 [1857] Proceedings Zoological Society London, p. 128.

*Parapholas ovoidea* Gould, H. and A. Adams 1856, Genera of Recent Mollusca 2, p. 330.

*Pholadidea ovoidea* Gould, Oldroyd 1924, Stanford University Publications, Geological Sciences 1, no. 1, p. 212, pl. 21, figs. 5-6 (not pl. 51, fig. 1a-b); Fitch, J.E., 1953, State of California, Department of Fish and Game, Fish Bulletin no. 90, p. 93, fig. 59.

*Distinctive characters.* Shell gaping widely at both ends in young specimens and only partially closing the pedal gape with a callum in the adult. Growing edge of the callum infolded over the beaks. Mesoplax similar to that found in *Zirfaea*. Shell divided into

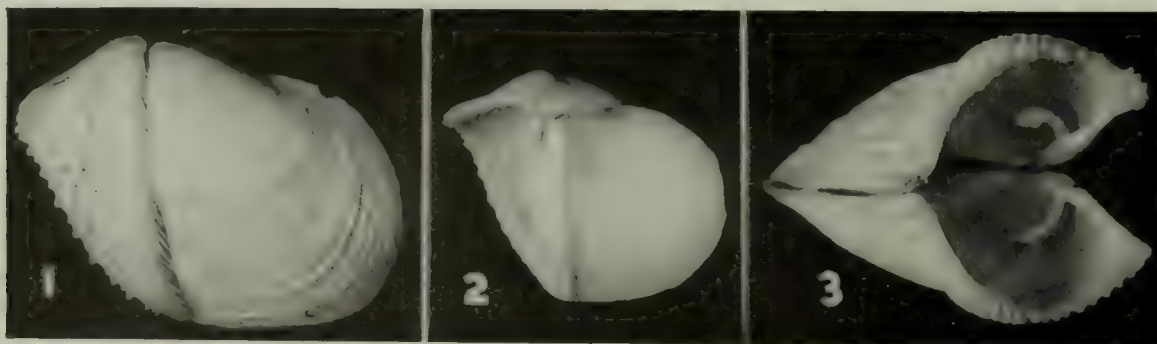


Plate 36. *Chaceia ovoidea* Gould. White Point, San Pedro, California (natural size). Young working specimens. Fig. 1. External view of valves showing the pronounced constriction of the shell at the umbonal-ventral sulcus. Fig. 2. Internal view of valve showing the sulcus expressed internally as a ridge. Fig. 3. Ventral view of opposed valves showing the pedal gape extended to its fullest extent.

<sup>1</sup> Named in honor of Mr. E. P. Chace of Lomita, California.

two portions by a very pronounced umbonal-ventral sulcus, the anterior portion tapering to a point on the ventral margin at the sulcus. Siphons very large, not capable of retraction within the shell, having large oval to elongate orange chitinous patches, and being strongly papillose to warty at the tip.

*Description.* Shell reaching 115.5 mm. (about  $4\frac{1}{2}$  inches) in length and 71 mm. (about  $2\frac{3}{4}$  inches) in height, broadly oval in outline, inflated, rather light in structure but strong and producing a partial callum in the adult stage. Immature specimens strongly beaked anteriorly with a nearly circular pedal gape. Posteriorly they are broadly rounded and widely gaping. Shell divided into two well defined areas by a pronounced umbonal-ventral sulcus. Anterior portion sculptured with close-set, upturned, undulating, concentric ridges and rather weak radial ribs which are indicated mainly by the radial arrangement of the rows of undulations. Young specimens occasionally have imbrications produced where the concentric ridges and radial ribs cross one another. Posterior portion sculptured with strongly marked concentric ridges which are definite extensions through the sulcus of the ridges of the anterior slope. Umbonal reflections simple, rather broad, closely appressed over the umbos, but usually free anteriorly. In adult specimens the pedal gape is partially closed by the callum which is sculptured by fine growth lines. The callum extends dorsally between the beaks and over the umbonal reflections and, doubling upon itself, forms a partial enclosure for the anterior adductor muscle. Between the beaks the callum is folded inward. Protoplax absent, being replaced by a dorsal extension of the callum. Mesoplax rather small, transverse, broadly V-shaped, in one piece and

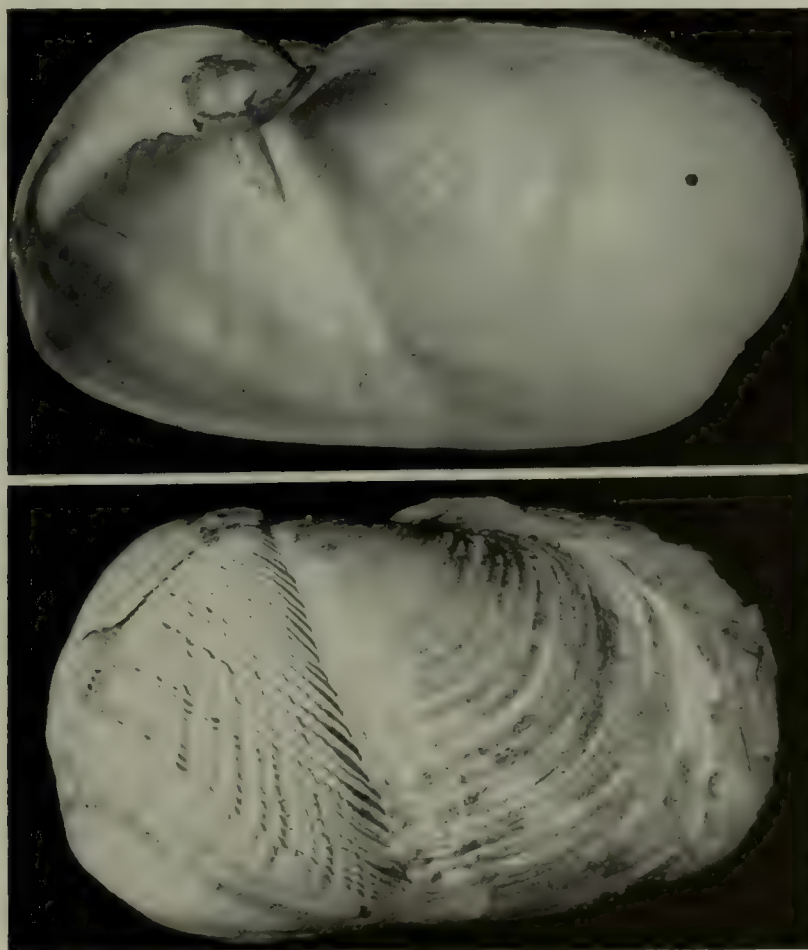
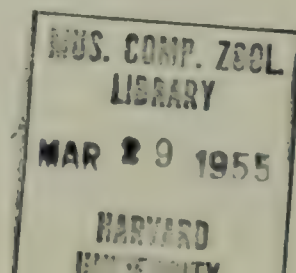


Plate 37. *Chaceia ovoidea* Gould. Anaheim Bay, California (natural size). Upper figure, inside of valve of an adult specimen showing the infolding of the callum over the beaks, the muscle scars and the pallial sinus. Lower figure, outside of valve showing strong umbonal-ventral sulcus and pronounced ridges on the posterior slope.



somewhat similar to that found in *Zirfaea*. Occasionally in old specimens the dorsal margin of the mesoplax appears to be extended anteriorly as a result of the deposition of calcium in the periostracum covering the area between the mesoplax and the callum. Interior of the shell white and usually glazed. Umbonal-ventral sulcus evident internally as a pronounced ridge. Muscle scars well marked, especially in older specimens. Pallial sinus extending anteriorly beyond the umbonal-ventral ridge. Apophyses small, solid, strong, and extending from beneath the umbos at an angle paralleling the umbonal-ventral ridge. Periostracum thin, light straw-yellow in color and persistent.

Siphons very large, not capable of retraction within the shell, and they may be extended 6 to 8 times the length of the shell. Anterior portion of the siphons covered with a moderately heavy golden to red-brown periostracum which extends dorsally up between the valves and ventrally covers that area in the adult not covered by the callum. Pos-

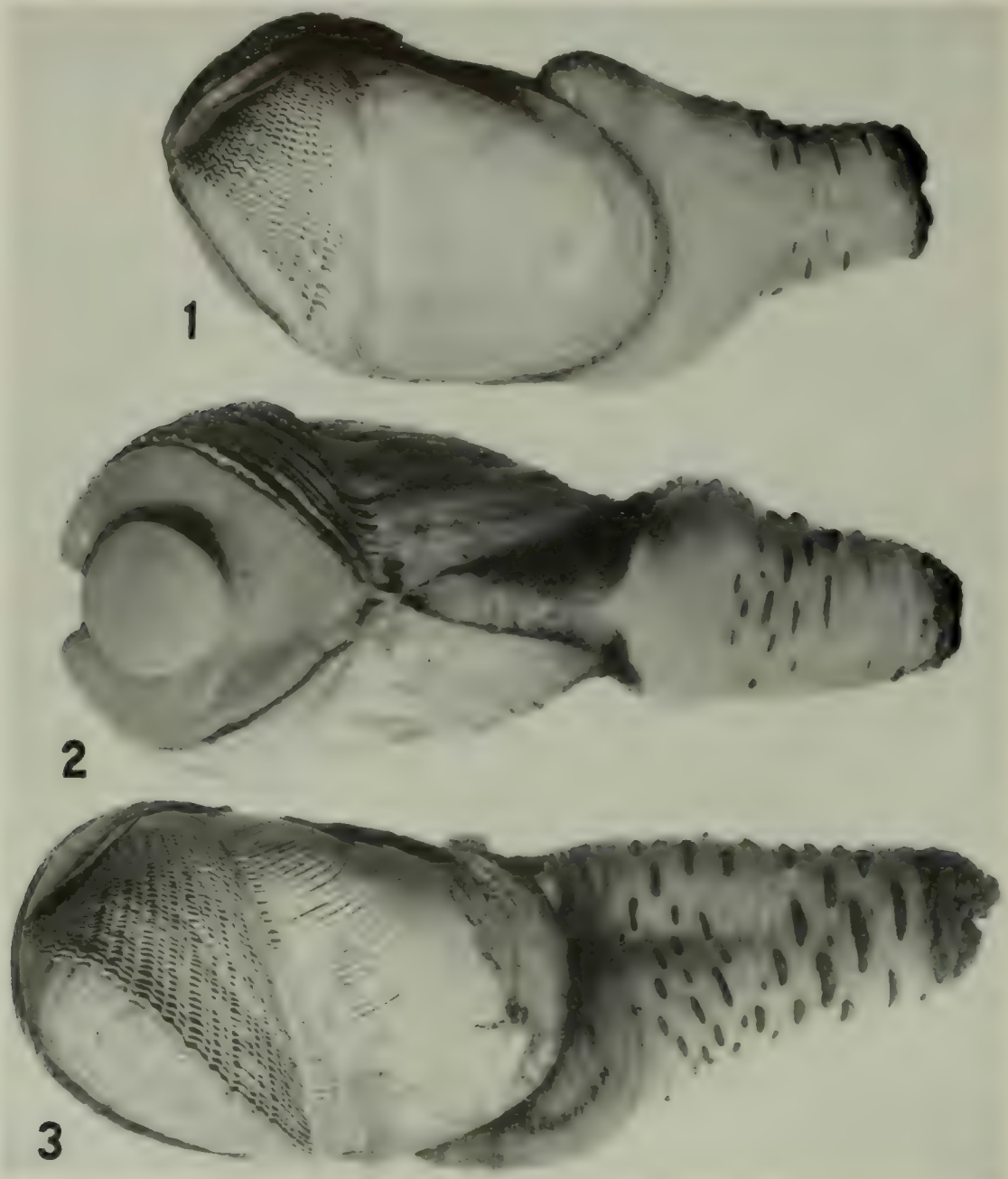


Plate 38. *Chaceia ovoidea* Gould. Figs. 1-2, White Point, San Pedro, California. Fig. 1. Specimen showing the beginning of the production of the callum and the siphons contracted to their fullest extent. Fig. 2. Ventral view of a young specimen showing valves in normal position, coming in contact only at the base of the umbonal-ventral ridge, the point on which the valves rock when boring (about  $1\frac{1}{4}x$ ). Fig. 3. Adult specimen with fully developed callum from Carpenteria, California (about  $\frac{2}{3}$  natural size). Note the large chitinous patches and the warty appearance of the tip of the siphons.

All photographs received through the kindness of J. E. Fitch of the California Fisheries Laboratory.

terior to the periostracal covering, the siphons are grayish-white and have pronounced oval to long, crescent-shaped, orange-brown chitinous patches. These patches are somewhat irregularly spaced but are most abundant near the posterior end. The tip of the siphon is dark red-brown to dark purple in color and strongly papillose to warty. The siphonal apertures are circled with white. Foot in young specimens large, broadly oval in outline and truncate. It is atrophied in the adult. Foot and surrounding mantle white to light purple-gray in color.

length *	height	ratio h:l	
115.5 mm.	71.0 mm.	1.62	Carpenteria, California
103.0	70.0	1.47	“ “
85.0	45.0	1.88	Anaheim Landing, California
73.5	48.0	1.53	Bahía San Bartolomé, Baja California
55.5	38.0	1.46	“ “ “ “ “

\* All specimens measured were adults

*Types.* The location of the type specimen of *Pholas ovoidea* Gould is unknown. The type locality is Monterey Bay, California, Major Rich, collector.

*Remarks.* *Chaceia ovoidea* Gould is a very distinctive and easily recognized species. When the entire animal is at hand, the very large siphons with conspicuous orange chitinous patches and the incomplete, infolded callum easily distinguish it from all other species. The young stage is most easily confused with young, truncate specimens of *Zirfaea pilsbryi* Lowe, the shells of the two species having about the same weight and the periostracum of both being thin and light straw-yellow in color. In *C. ovoidea* Gould, however, the two portions of the shell are much more clearly marked, the umbonal-ventral sulcus being much more pronounced, resulting in a marked constriction of the shell. In addition, the anterior portion of *C. ovoidea* Gould tapers to a point on the ventral margin at the sulcus. The sculpture of the posterior portion of *C. ovoidea* Gould is stronger than that of *Z. pilsbryi* Lowe and the posterior slope is far more inflated. The sculpture on the anterior slope of *Z. pilsbryi* Lowe consists of rather strong, pointed imbrications whereas in *C. ovoidea* Gould the sculpture consists of upturned, undulating ridges. From young of *Penitella penita* Conrad and *Penitella gabbi* Tryon this species differs by having a much more inflated posterior slope, a much thinner periostracum, a wider pedal gape

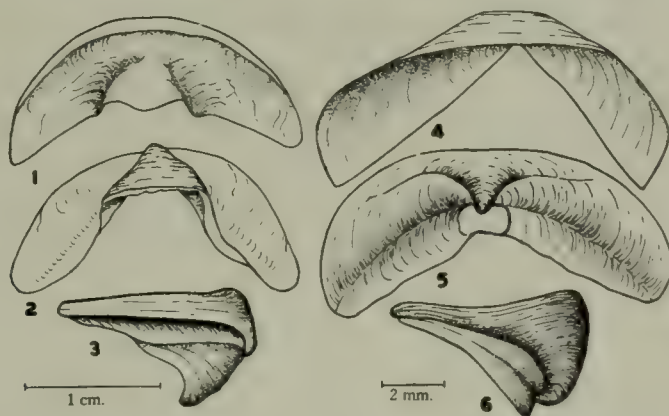


Plate 39. Mesoplax of *Chaceia ovoidea* Gould. Figs. 1-3. Dorsal, ventral and side view of the mesoplax of an adult specimen from Bahía San Bartolomé, Baja California. This shows the great similarity of the dorsal plate in *Chaceia* to that in *Zirfaea*. Figs. 4-6. Dorsal, ventral and side view of the mesoplax from a young specimen taken at White Point, San Pedro, California.

and in having the apophyses paralleling the umbonal-ventral ridge rather than projecting anteriorly from beneath the umbos at a sharp angle. From the adults of these two species it differs by having an incomplete callum. From *Penitella fitchi* Turner, the only other species in the eastern Pacific with an incomplete callum, *C. ovoidea* differs by its siphons, its mesoplax and by lacking the siphonoplax.

There has been considerable confusion as to the identity of this species, probably due to the fact that *C. ovoidea* Gould is a rather rare species with a somewhat restricted range and because Gould's figure and description are rather poor. Unless one has an adult specimen of *ovoidea*, the figures of Gould could easily be interpreted as either *Penitella penita* Conrad, without its siphonoplax, or as *P. gabbi* Tryon. The matter was further confused when I. Oldroyd (1924, pl. 51, figs. 1a-b) figured *P. gabbi* Tryon as *ovoidea* Gould.

Mr. E. P. Chace has written that at White Point, San Pedro, California, *C. ovoidea* Gould lives in soft shale rock along with *P. penita* Conrad, *P. gabbi* Tryon and *Parapholas californica* Conrad, but specimens are much less abundant. He collected some large specimens with Mr. J. Fitch at Carpenteria, California and found that they made an excellent chowder. According to Mr. Fitch, *ovoidea* may bore to a depth of 18 to 21 inches, which is much deeper than that of the species with which it is found living.

*Range.* From Santa Cruz, California (J. E. Fitch, 1953, p. 93) south to San Diego, California and at Bahía San Bartolomé, Baja California.

*Specimens examined.* CALIFORNIA: Santa Barbara (MCZ); Carpenteria (E. P. Chace; J. E. Fitch; A. Hancock Foundation); White Point, San Pedro (E. P. Chace); Anaheim Landing (W. J. Eyerdam); San Diego (ANSP; MCZ). MEXICO: Bahía San Bartolomé, Baja California (J. E. Fitch).

### Genus *Penitella* Valenciennes

*Penitella* Valenciennes 1846 [in] Abel du Petit-Thouars, Voyage Autour du Monde sur la Frégate La Vénus, Atlas de Zoologie, Mollusques, plate 24.

*Penicilla* 'Valenciennes' Conrad 1854, Journal Academy Natural Sciences Philadelphia (2) 2, p. 335 (error for *Penitella* Valenciennes).

Shells small to moderate in size, the larger species reaching about 95 mm. (about  $3\frac{3}{4}$  inches) in length, oval in outline, divided into two distinct regions by an umbonal-ventral sulcus and producing a callum in the adult stage. Shell beaked and widely gaping anteriorly in the young stage, with a nearly circular pedal gape. Valves rounded to truncate and closed posteriorly, the siphon being capable of complete retraction within the shell. Umbonal reflections variable, ranging from those which are thin and very closely appressed so that the sculpture of the shell shows through, to those which are heavy and free anterior to the umbos. Protoplax lacking, being replaced by the dorsal extension of the callum. Mesoplax transverse, in one piece and, in young specimens, very similar to that found in *Zirfaea*. In the adult, a dorsal portion is added to the mesoplax which grows forward and encloses the posterior portion of the anterior adductor muscle. Metaplax and hypoplax lacking, Siphonoplax variable, present or absent. Siphonal tube lacking.

*Penitella* Valenciennes has been considered a subgenus of *Pholadidea* by many authors. However, the form of the mesoplax, the type of siphonoplax, the complete lack of a

siphonal tube and the absence of any indication of a metaplast or hypoplast seem sufficient reason to consider this group of species as a genus. In *Pholadidea*, the mesoplast is divided longitudinally into two parts and the two halves of the siphonoplast are somewhat fused to form a tube. In *Penitella* the mesoplast is in one piece and the two portions of the siphonoplast are never fused and are often diverging. In addition, the apophyses of the *Pholadidea* are very small, narrow and fragile, while those of *Penitella*, though often short, are heavy, expanded and blade-like at the free end.

Unfortunately Stoliczka in 1870, Dall in 1898, and Lamy in 1926, were in error when they considered *P. penita* Conrad as the type of the genus *Penitella*. This species was not included by Valenciennes at the time the genus was instituted by him.

The genus *Penitella* Valenciennes, so far as now known, is restricted in its distribution to the Eastern and Northern Pacific.

Genotype, *Penitella conradi* Valenciennes, subsequent designation Habe 1952.

### Key to the species of *Penitella*

(based on adult specimens)

1. Adults with a complete callum . . . . . 2  
    Adults with an incomplete callum . . . . . *fitchi*
2. Umbonal reflection closely appressed for the entire length, siphonoplast present, siphons smooth . . . . . 3  
    Umbonal reflection free anteriorly, siphonoplast absent, siphons pustulose . . . . . *gabbi*
3. Siphonoplast composed of heavy, flexible chitinous flaps which are not lined with calcareous granules. Mesoplast pointed posteriorly, truncate anteriorly and having lateral wings . . . . . *penita*  
    Siphonoplast not flexible, composed of a heavy chitinous outer layer lined with coarse calcareous granules. Mesoplast truncate posteriorly, pointed anteriorly and lacking lateral wings . . . . . *conradi*

### *Penitella fitchi*, new species<sup>1</sup>

Plates 40-42

*Distinctive characters.* Shell having thin, very closely appressed umbonal reflections, producing only a partial callum in the adult stage and having the siphonoplast composed of numerous chitinous leaf-like layers. Mesoplast broadly rounded to truncate posteriorly, rounded anteriorly and lacking lateral wings.

*Description.* Shell white, oval in outline, reaching 49.5 mm. (about 2 inches) in length and 35.5 mm. (about 1 $\frac{3}{8}$  inches) in height, solid in structure and producing a partial callum and a siphonoplast in the adult stage. Immature specimens beaked and gaping widely anteriorly, rounded and closed posteriorly. Valves divided into two distinct and very unequal parts by a pronounced umbonal-ventral sulcus. Anterior portion small, about  $\frac{1}{3}$  the posterior portion, tapering to a point on the ventral margin at the umbonal-ventral sulcus and sculptured by very close-set, upturned undulating ridges and radial ribs. The ribs are expressed mainly by the radial arrangement of the undulations. Posterior portion broadly rounded in young specimens, becoming proportionately longer and more tapering in the

<sup>1</sup>This species is named for John E. Fitch of the California Fisheries Laboratory, Terminal Island Station, who has been most helpful in obtaining material for us and who collected this species.

adult and sculptured with fine growth lines. Umbos located near the anterior third of the shell and covered, in young specimens, with broad, simple umbonal reflections which are closely appressed for their entire length and through which the sculpture of the shell can be seen. In the adult, the pedal gape is partially closed by a rather heavy, solid callum which extends dorsally up between the beaks and over the umbonal reflection to form the enclosure for the anterior portion of the anterior adductor muscle. The callum is sculptured with growth lines and there is a slight indication of the forward extension of the radial ribs. Anteriorly a broad oval area remains after the callum is completed and this is covered with a heavy gray-brown periostracum, only a minute pore actually remaining open in the adult stage. Protoplax lacking, being replaced by the dorsal extension of the callum. Mesoplax in young specimens broad, thin, nearly flat, rounded posteriorly and with a deep embayment anteriorly. In the adult stage the mesoplax extends dorsally and anteriorly forming an enclosure for the posterior portion of the anterior adductor muscle. Mesoplax of the adult large, heavy, more or less triangular in outline, rounded posteriorly and pointed anteriorly. Siphonoplax composed of numerous leaf-like layers of gray-brown chitin, the leaves becoming progressively longer from the inside out. These extend well up the dorsal margins of the valves nearly to the umbos, and on the ventral margin extend nearly to the umbonal-ventral sulcus. The number of layers increases with age, a young specimen just beginning to produce a callum usually having only two layers while an old mature specimen may have eleven or more. Metaplax and hypoplax lacking.

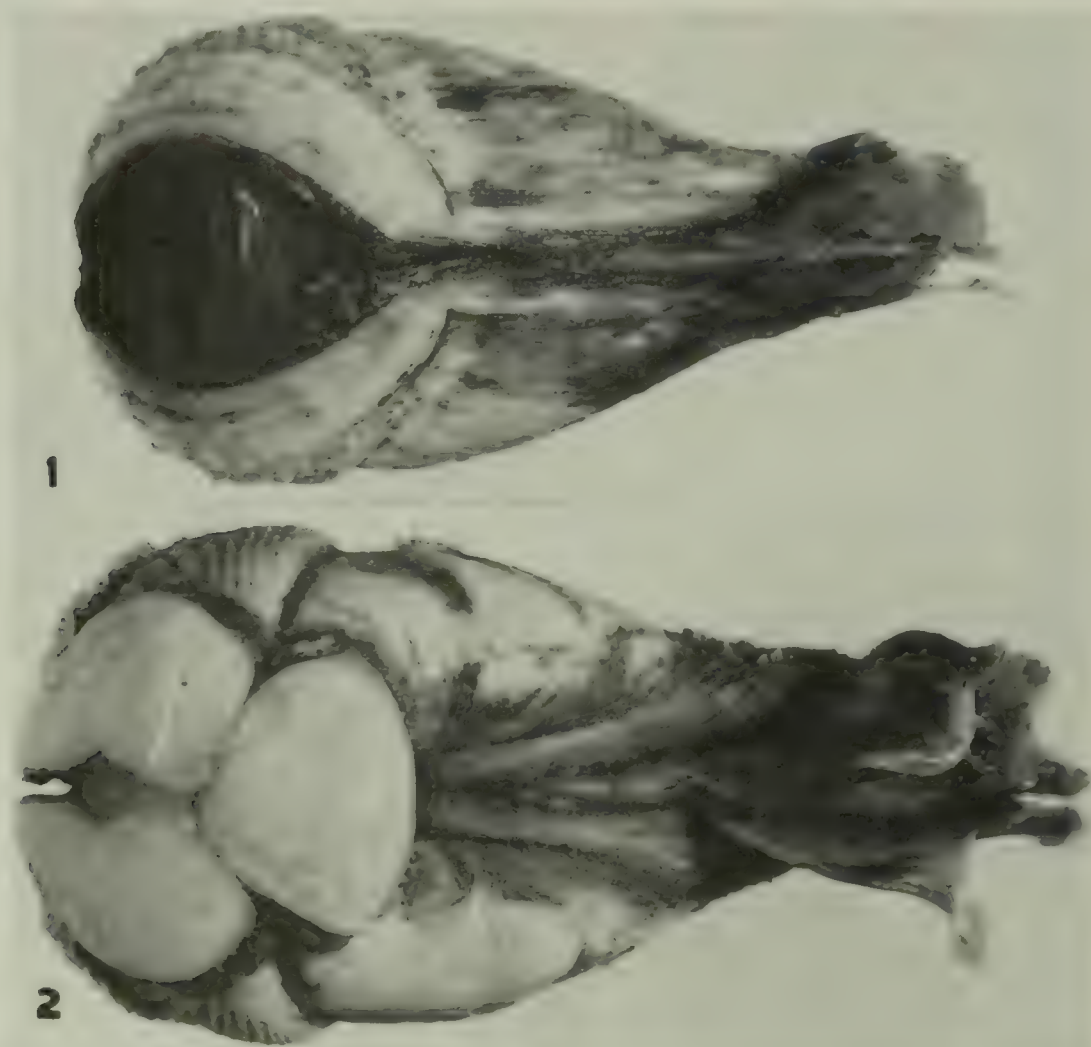


Plate 40. *Penitella fitchi* Turner. Bahía San Bartolomé, Baja California. Fig. 1. Paratype. Ventral view to show the partial callum. Fig. 2. Holotype. Dorsal view to show the triangular mesoplax and the multi-layered siphonoplax. (Both about 2x.)

Periostracum thin, medium gray-brown to yellow-brown in color, and deciduous. Interior of shell white and glazed. Umbonal-ventral sulcus visible internally as a broad, smooth ridge. Muscle scars large, pronounced and roughened. Pallial sinus broad and deep, extending anteriorly beyond the umbonal-ventral ridge. Apophyses solid, expanded and blade-like at the free end and extending anteriorly from beneath the umbos at a sharp angle.

Siphons united, white to ivory in color, smooth and capable of complete retraction within the shell. Incurrent siphon with six large and numerous small cirri which extend for a short distance internally as ridges. Excurrent siphon about one half the diameter of the incurrent siphon and with numerous small cirri. Externally the tips of the siphons are marked with a narrow band of dark red-brown vermiculations and spots. Foot and mantle white to ivory. In young specimens the foot is large, nearly circular in outline and truncate. It is atrophied in the adult. The above description of the soft parts is based upon preserved material.

length *	height	ratio h:l	
49.5 mm.	35.5 mm.	1.4	Holotype
40.0	35.0	1.1	Paratype
38.0	21.5	1.7	"
16.5	11.5	1.4	"

\* All specimens measured had a callum

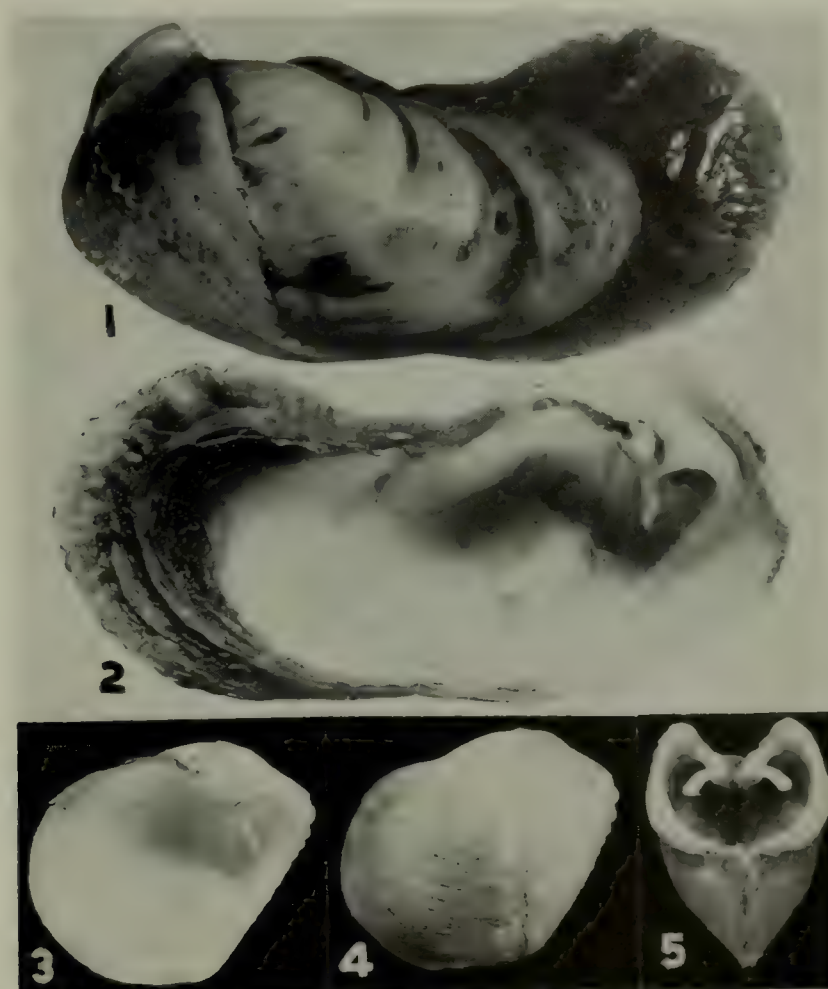


Plate 41. *Penitella fitchi* Turner. Bahía San Bartolomé, Baja California. Fig. 1. Lateral view to show the small anterior portion and the siphonoplax. Fig. 2. Internal view of adult showing the incurving of the callum over the beaks, the muscle scars and the apophysis. Fig. 3. Internal view of young specimen showing the proportionately much shorter posterior slope, the muscle scars and the expanded apophysis. Fig. 4. External view of young specimen showing the very closely appressed umbonal reflection and the triangular shape of the anterior portion. Fig. 5. Ventral view of opposed valves showing the small ventral condyle, the apophyses and the pedal gape. (All paratypes, all natural size.)

*Types.* Holotype, Museum of Comparative Zoölogy, no. 189413, from Bahía San Bartolomé, Baja California, John E. Fitch, collector. Paratypes from the same locality collected by J. E. Fitch, E. Dwyer and D. Joseph, are in the Museum of Comparative Zoölogy, the United States National Museum, Stanford University, the Academy of Natural Sciences Philadelphia and the collection of Dr. S. S. Berry.

*Remarks.* *Penitella fitchi* Turner is a very distinctive species, especially in the adult stage, and it does not appear to be closely related to any other species in this genus. It is, perhaps, most closely related to *Penitella conradi* Valenciennes as both species have a very similar young stage, and the mesoplax in the young and adult stage of both species are close in general outline. However, *P. fitchi* Turner differs from *P. conradi* Valenciennes by having only a partial callum and by having the siphonoplax composed of numerous thin chitinous leaves. *Penitella penita* Conrad, a species which *P. fitchi* Turner approaches in size and with which it is found living, differs in both the form of the mesoplax and the siphonoplax and in having a complete rather than partial callum. From *Chaccia ovoidea* Gould, the only other species which produces an incomplete callum, *P. fitchi* Turner differs by having a siphonoplax and by having the shell closed posteriorly, the siphons being capable of complete retraction within the shell. In addition, the siphons of *P. fitchi* Turner are smooth while those of *C. ovoidea* Gould have large, orange, chitinous patches.

Mr. John E. Fitch has written that *P. fitchi* Turner was boring into the sedimentary rocks on the north side of Bahía San Bartolomé [Turtle Bay], Baja California along with equal numbers of *P. penita* Conrad and a few *C. ovoidea* Gould. They appeared to bore to about the same depth as *P. penita*. The outstanding difference between the two species seen *in situ* is the greater amount of color on the siphons of *penita*—the siphons of *fitchi* appearing creamy white when extended.

*Range.* Known only from the type locality, Bahía San Bartolomé, Baja California.

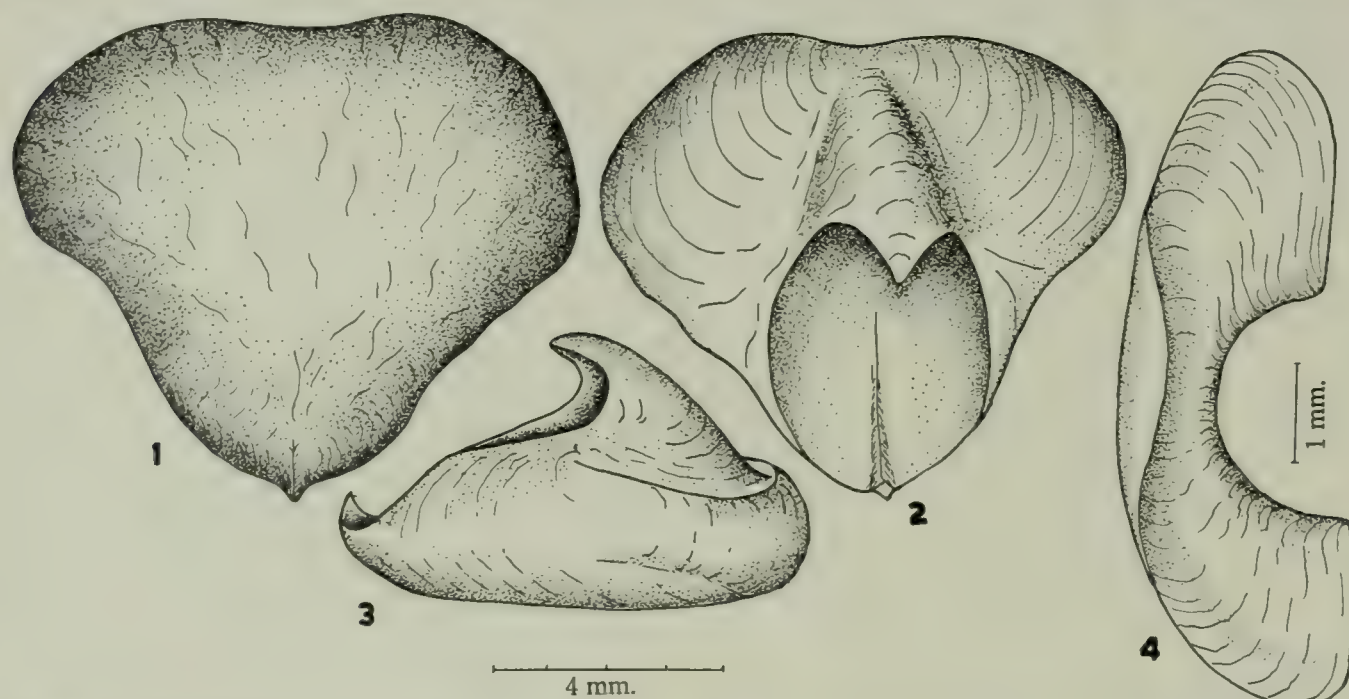


Plate 42. Mesoplax of *Penitella fitchi* Turner. Fig. 1. Dorsal view of the mesoplax showing the truncate posterior margin and the pointed anterior end. Fig. 2. Ventral view of the mesoplax showing the large cavity. Fig. 3. Side view of the same specimen. Fig. 4. Dorsal view of the mesoplax of a young specimen. All from specimens collected at Bahía San Bartolomé, Baja California.

*Specimens examined.* MEXICO: Bahía San Bartolomé, Baja California (J. E. Fitch).

***Penitella conradi Valenciennes***

Plates 43-46; Plate 72, figs. 1-2

*Penitella conradi* Valenciennes 1846 [in] Abel du Petit-Thouars, Voyage Autour du Monde sur la Frégate La Vénus, Atlas de Zoologie, Mollusques, plate 24, fig. 1 (no locality given); Lamy 1921, Bulletin Muséum d'Histoire Naturelle Paris **27**, p. 179 (Monterey, California, from type label).

*Navea subglobosa* Gray 1851, Annals Magazine Natural History (2) **8**, p. 385 (California, in hole in a shell); H. and A. Adams 1856, The Genera of Recent Mollusca **2**, p. 328, pl. 89, fig. 6a-b; Lamy 1925, Journal de Conchyliologie **69**, p. 103.

*Martesia intercalata* Carpenter 1855, Catalogue of the Reigen Collection of Mazatlan Mollusca, p. 13 (Mazatlan, Mexico in *Spondylus lamarckii*).

*Navea newcombii* Tryon 1865, American Journal of Conchology **1**, p. 39, 285, pl. 2, figs. 1-3 (Lower California in *Haliotis*, W. Newcomb, collector).

*Penitella parva* Tryon 1865, American Journal of Conchology **1**, p. 39, pl. 2, figs. 4-5 (Lower California, in *Haliotis*, W. Newcomb, collector).

*Distinctive characters.* Shell usually found boring into *Haliotis* or other shells; occasional specimens are found in clay and soft stone. Umbonal reflections broad and closely appressed for their entire length. Mesoplax truncate posteriorly, pointed anteriorly and lacking lateral wings. Siphonoplax heavy, not diverging and composed of a chitinous outer layer which is lined with a white, granular, calcareous deposit.

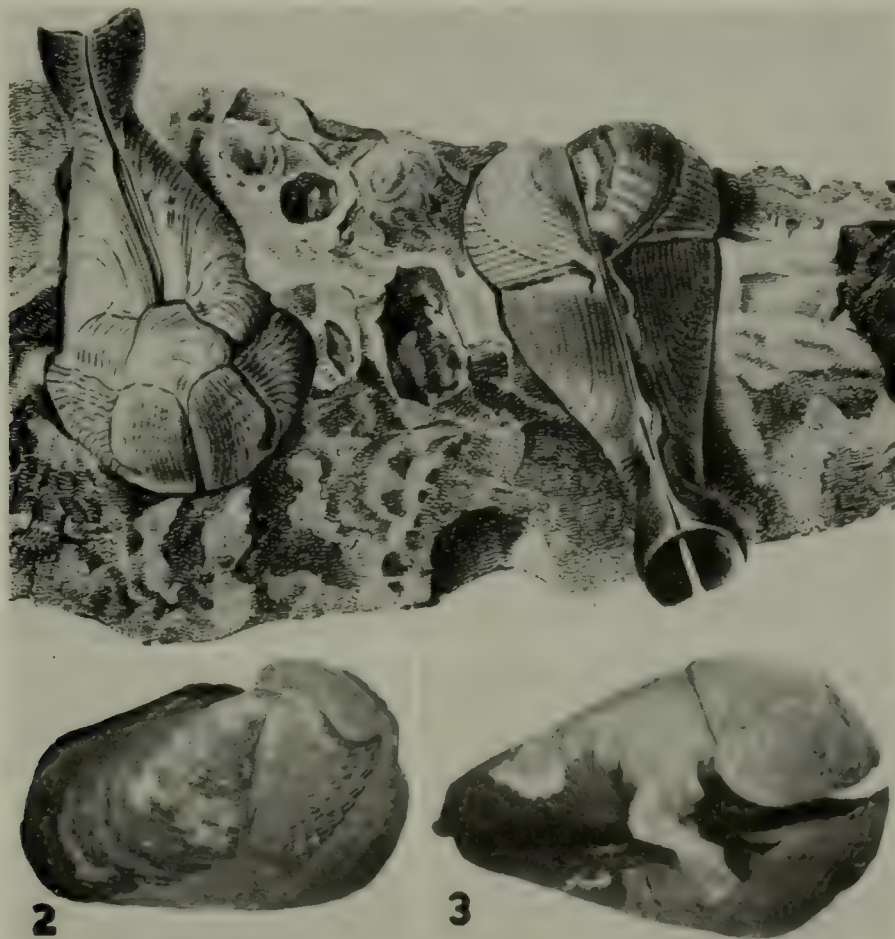


Plate 43. *Penitella conradi* Valenciennes. Fig. 1. A copy of the original figures of the species as given by Valenciennes in the 'Voyage de la Vénus,' pl. 24, fig. 1. Fig. 2. Side view of a type specimen. Fig. 3. Dorsal view of the type.

Photographs of the type specimens were received through the kindness of Dr. Max de Jardin of the Muséum d'Histoire Naturelle, Paris, France.

*Description.* Shell reaching about 33 mm. ( $1\frac{1}{4}$  inches) in length and 16.5 mm. (about  $\frac{1}{2}$  inch) in height, generally oval in outline, solid in structure and producing a callum and siphonoplax in the adult stage. Immature specimens beaked and widely gaping anteriorly, tapering posteriorly to a rounded and closed posterior margin. Shell divided into two distinct regions by a pronounced umbonal-ventral sulcus. Anterior portion about one third the posterior portion, tapering to a point on the ventral margin at the umbonal-ventral sulcus, and sculptured with very fine, close-set, upturned, undulating, concentric ridges and weak radial ribs which are expressed mainly by the radial arrangement of the undulations. Posterior portion sculptured with concentric growth lines. Umbonal reflections wide, closely appressed and with thickened, elevated, longitudinal ridges over the umbos. In adult specimens the pedal gape is closed by a heavy callum which is sculptured with very faint growth lines and faint ridges indicating the extension forward of the radial ribs. Protoplax lacking, being replaced by the dorsal extension of the callum. Mesoplax in young specimens thin, nearly flat, and more or less semicircular in outline. In adult specimens the dorsal portion of the mesoplax extends anteriorly and encloses the posterior portion of the anterior adductor muscle. It is broadly rounded to truncate posteriorly and pointed anteriorly, fitting in between the two halves of the reflected callum. Metaplax and hypoplax lacking. Siphonoplax dark brown in color, covered with

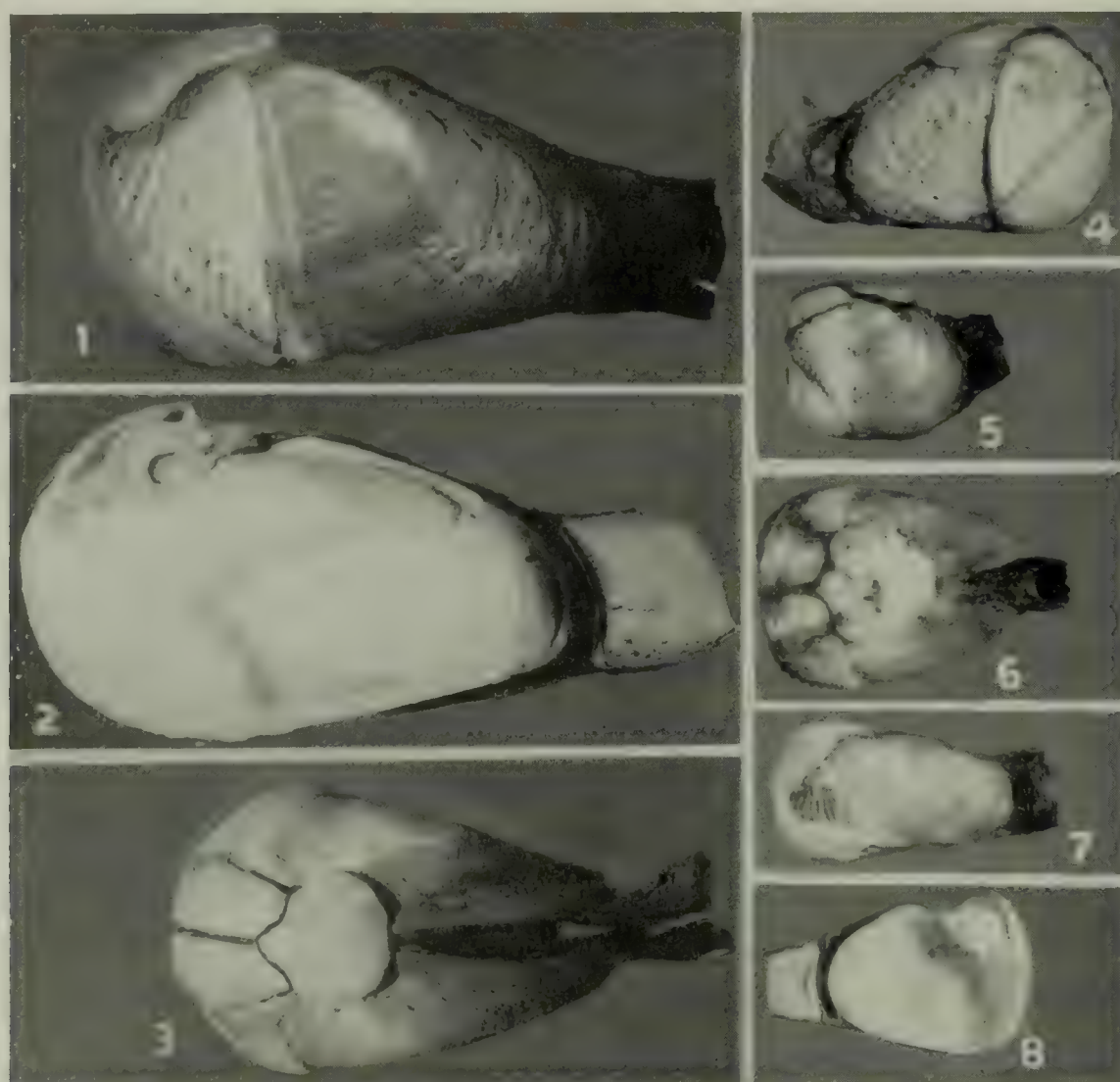


Plate 44. *Penitella conradi* Valenciennes. Figs. 1-3. Del Monte Beach, Monterey Bay, California. Specimens boring in soft shale (about 3x). Figs. 4-8. Monterey Bay, California. Specimens boring in *Haliotis rufescens* brought in at Monterey. Such specimens are always small and more or less deformed (about 2x). Figs. 2 and 8 show the white lining of the siphonoplax. Apophysis broken in fig. 2. Figs. 3 and 6 show the typical mesoplax which is pointed anteriorly and lacks lateral wings.

a heavy periostracum and lined internally with a white, granular, calcareous deposit. The two halves of the siphonoplax come together to form a cup-like structure which is very variable both in length and diameter. Periostracum especially heavy on the posterior slope, dark brown to nearly black in color and persistent. Interior of shell white and generally chalky. Umbonal-ventral sulcus evident internally as a rather weak rib. Muscle scars large, pronounced and usually roughened. Pallial sinus broad and deep, extending anteriorly beyond the umbonal-ventral ridge. Apophyses solid, expanded and blade-like at the free end, and extending from beneath the umbos anteriorly at a sharp angle, often nearly reaching the anterior margin of the shell. Occasionally the apophyses are rather deformed and irregular.

Siphons united, small, white and devoid of periostracum. They probably do not extend more than half the length of the shell and are capable of complete retraction within the shell. Aperture of the incurrent siphon surrounded with numerous cirri which are flecked with dark red-brown markings. Excurrent siphon about one half the diameter of the incurrent siphon, having much smaller cirri and fewer, smaller flecks. Foot and mantle white to light ivory in color. Foot in young specimens large, nearly circular in outline and truncate; it is atrophied in the adult. The above description of the soft parts was based upon preserved material.

length*	height	ratio h:l	
33.0 mm.	16.5 mm.	2.0	Del Monte Beach, Monterey, California (in shale)
30.0	16.2	1.8	" " " " " "
17.8	11.5	1.5	From <i>Haliotis rufescens</i> landed at Monterey, California
15.1	8.3	1.8	" " " " " "
8.1	5.5	1.5	" " " " " "
6.8	4.5	1.5	" " " " " "

\* All specimens measured had a complete callum

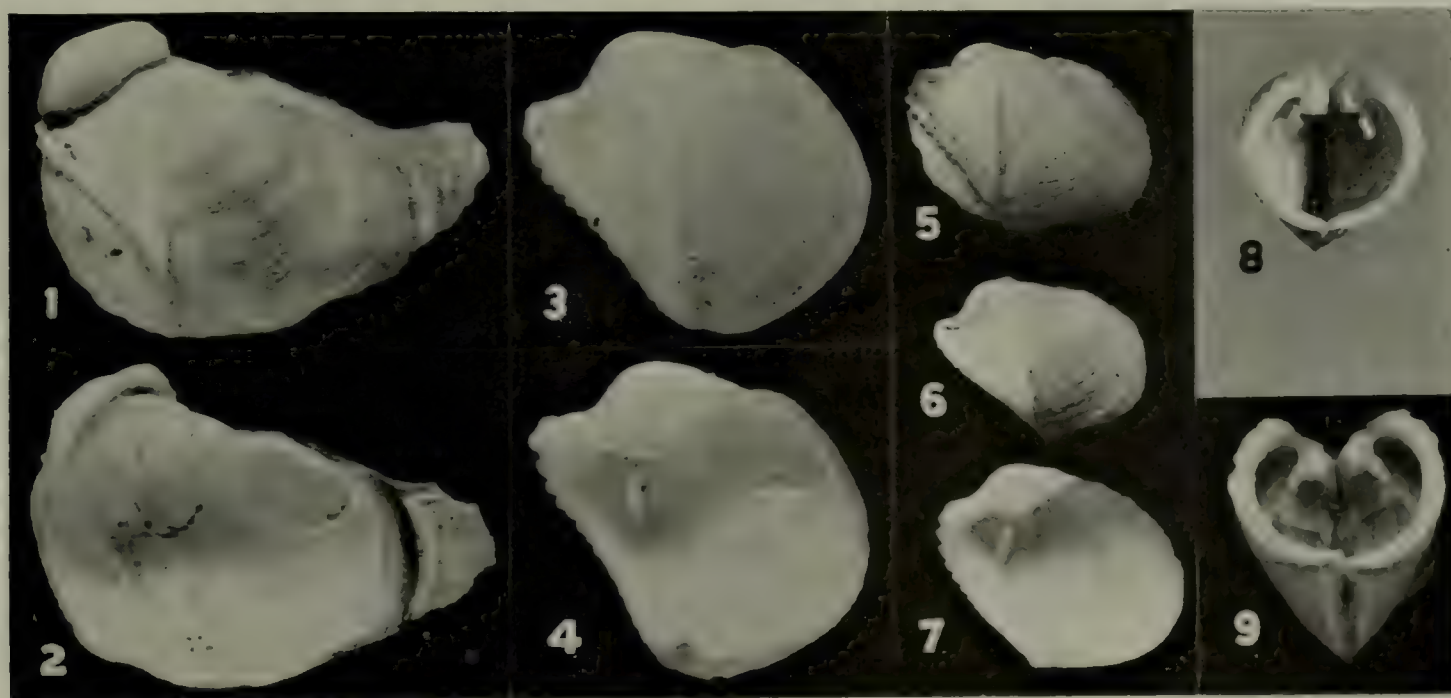


Plate 45. *Penitella conradi* Valenciennes. Figs. 1-2. Lectotype, *Penitella parva* Tryon (= *P. conradi* Valenciennes) Baja California (about  $4\frac{3}{4}x$ ). Figs. 3-4. Holotype, *Navea newcombi* Tryon (= *P. conradi* Valenciennes) Baja California (about  $4\frac{3}{4}x$ ). Figs. 5-9. Monterey Bay, California from *Haliotis* (about  $2\frac{1}{2}x$ ). Fig. 5. Specimen with partially grown callum and showing the beginning of the elongation of the posterior slope. Fig. 6. Young specimen. Fig. 7. Internal view of young specimen showing the large muscle scars, pallial sinus and apophysis. Fig. 8. View of pedal gape to show the blade-like apophyses projecting forward. Fig. 9. Ventral view of opposed valves showing the condyles and closed posterior margin.

*Types.* The types of *Penitella conradi* Valenciennes are in the Paris Museum; the type locality is Monterey, California, from the type label (Lamy 1921). The types of *Navea subglobosa* Gray are in the British Museum: the type locality is California. The lectotype of *Penitella parva* Tryon is in the Academy of Natural Sciences Philadelphia, no. 50999, from Lower California, obtained from a *Haliotis*, W. Newcomb, collector. The holotype of *Navea newcombii* Tryon from the same locality is also in Philadelphia, no. 51069. The location of the types of *Martesia intercalata* Carpenter is unknown. They are not in the Hanley collection in the British Museum. However, a sketch made by P. P. Carpenter of the specimens in the Hanley collection is in the British Museum and we reproduce a photograph of this sketch. Specimens so named by Carpenter are in the United States National Museum and the Redpath Museum, Ontario, Canada.

*Remarks.* *Penitella conradi* Valenciennes is close in its relationship to *P. penita* Conrad and *P. gabbi* Tryon, and has been confused with both these species. It is the species commonly found in *Haliotis*, but may also be found boring into other shells or into soft rock or clay along with *P. penita* Conrad and *P. gabbi* Tryon. From adult *P. penita* Conrad it differs by having a heavier, less diverging siphonoplax with a pronounced white, granular, calcareous lining. The mesoplax of *P. conradi* is truncate posteriorly and pointed anteriorly, fitting in between the reflected portions of the dorsal extension of the callum, and in addition, lacks the lateral wings found in the other two species. From *P. gabbi* Tryon it differs by having very closely appressed umbonal reflections and in having a siphonoplax. The young of *P. conradi* Valenciennes are rather difficult to distinguish from the young of other species in this genus. From the young of *P. gabbi* Tryon it is distinguished by its umbonal reflection and from the young of *P. penita* Conrad, which also has a wide and closely appressed umbonal reflection, it can be distinguished by the apophyses, which generally project forward at a much sharper angle, by the elevated longitudinal ridges over the umbos, the shorter, more rounded, posterior slope and the more upturned concentric ridges on the anterior portion. Young specimens of *P. conradi* Valenciennes boring into clay and soft rock are most difficult to distinguish, but the shorter, more rounded, posterior slope and the shape of the mesoplax will separate them.

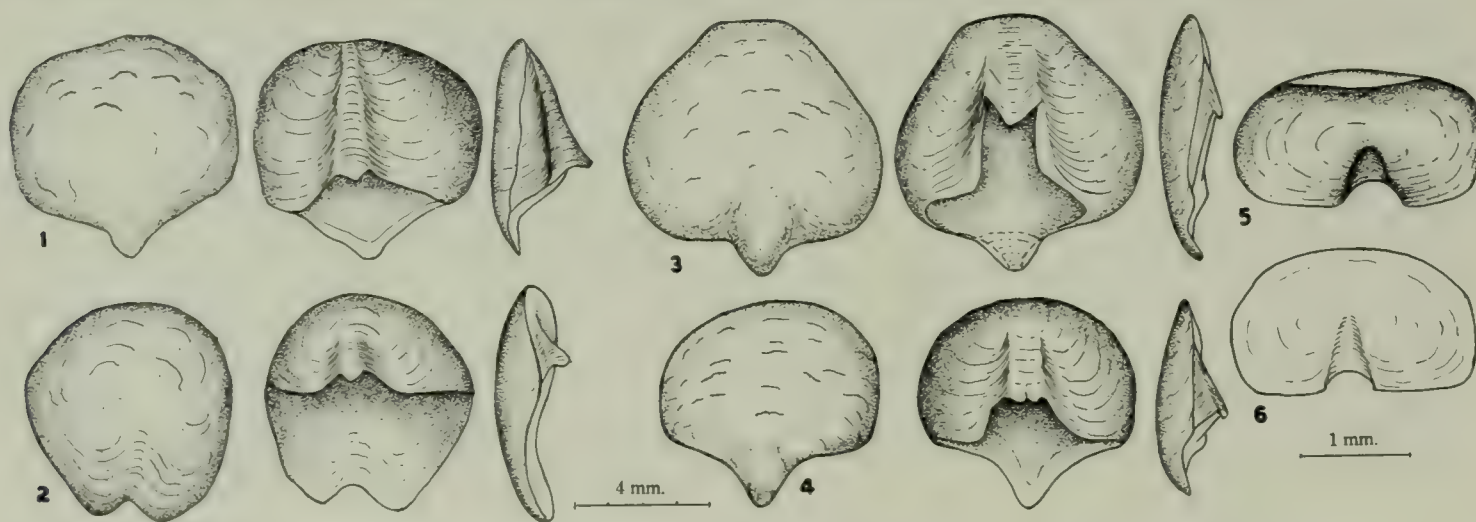


Plate 46. Mesoplax of *Penitella conradi* Valenciennes. Fig. 1. Dorsal, ventral and side view of the mesoplax of a specimen taken from shale, showing the pointed anterior end. Fig. 2. Dorsal, ventral and side views of the mesoplax of a much malformed specimen taken from a *Haliotis*. Figs. 3-4. Plates from more typical specimens boring in *Haliotis*. The series is given to show the range of variation that may be expected. Fig. 5. Dorsal view of the mesoplax of a young specimen taken from a *Haliotis*. Fig. 6. Ventral view of the same specimen. All specimens are from Monterey Bay, California.

Two problems have confused the nomenclature of this species: one, the generally accepted idea that *P. parva* Tryon (= *P. conradi* Valenciennes) was restricted to boring into shells, and the other, the lack of understanding of the young form of this species. Probably as a result of the idea that the "*Haliotis* borer" was never found in clay and rock, Lamy (1921) considered *P. conradi* Valenciennes as a synonym of *P. penita* Conrad. Though Valenciennes never described *Penitella conradi*, his figures clearly show the characteristic mesoplax which is broadly rounded to truncate posteriorly, pointed anteriorly and lacks lateral wings. The umbonal reflections and the heavy, cupped, rather than diverging siphonoplax are also characteristic of the "*Haliotis* borer." In the large series of specimens, mostly *P. penita* Conrad, which were taken from the rocks at Del Monte Beach, Monterey Bay, California and Bahía San Bartolomé, Baja California we have found specimens of the "*Haliotis* borer" which match perfectly the illustrations by Valenciennes. On the basis of the material now available, there seems to be no question that *P. parva* Tryon and *P. conradi* Valenciennes refer to the same species—Tryon's material having come from a *Haliotis* while Valenciennes' specimens came from soft shale. Specimens boring into shells are nearly always deformed, often with the posterior portion and the siphonoplax greatly reduced. The specimens may be curved and dented to fit around obstructions in their burrows and the anterior portion of the shell is often deformed and flattened. In heavily infected *Haliotis* the specimens often run into each other's burrow. Regardless of whether the specimens are malformed ones from *Haliotis* or perfect ones from a clay bed, the characteristic mesoplax and siphonoplax as well as the granular muscle scars are always evident.

The young or working form of *P. conradi* Valenciennes has never been figured, and though specimens of this species with a half grown callum are rare we have seen several and figure one of them. By removing the callum and siphonoplax from numerous adult specimens of *P. conradi* Valenciennes we were able to show that the young stage of this species is identical with what has generally been referred to as *Navea subglobosa* Gray. It is interesting to note the *P. parva* Tryon and *Navea newcombi* Tryon were both taken from *Haliotis* collected in Baja California by W. Newcomb. Very possibly they both came from the same shell. This problem of placing the young stages of callum-building pholads in separate genera has appeared several times and undoubtedly before the entire family is completely studied several more species and genera will fall into synonymy.

*Penitella conradi* Valenciennes has been found boring into *Haliotis fulgens* Philippi, *H. rufescens* Sowerby, and *H. sorenseni* Bartsch, *Mytilus californianus* Conrad, *Astraea* sp., *Pododesmus* sp. and in soft rock. Mr. John Fitch has written that the borers do relatively little damage to the *Haliotis* so far as the food crop is concerned though they can be very abundant in some specimens.

*Range.* From Gualala, Mendocino County, California south at least as far as Bahía San Bartolomé, Baja California.

*Specimens examined.* CALIFORNIA: Gualala, Mendocino County (USNM); Stewarts Point and Shell Beach, Sonoma County (Hancock Foundation); Farallones, off San Francisco (Redpath Museum; USNM); Monterey Bay (MCZ; USNM; E. P. Chace; W. J. Eyerdam); Del Monte Beach, Monterey, in shale (E. P. Chace); Pacific Grove (S. S. Berry); Point Sur, Monterey County in 10 fathoms (M. Keen); 5 miles north of

Morro Rock (J. E. Fitch): White Point, San Pedro (J. E. Fitch; E. P. Chace; S. S. Berry: USNM); Laguna Beach, Orange County (S. S. Berry):  $1\frac{1}{2}$  mi. east of Cardwell Point, San Miguel Island: Anacapa Passage, Santa Cruz Island in 50 fathoms (both Hancock Foundation); Santa Catalina Island (USNM); San Clemente Island (J. E. Fitch): off San Clemente Island in 10 fathoms (S. S. Berry). MEXICO: off South Coronado Island: Isla Geronimo: Punta Santo Tomas and Santo Tomas Anchorage, all Baja California (all S. S. Berry); Bahía San Bartolomé, Baja California (J. E. Fitch; S. S. Berry); Todos Santos Bay, Baja California (ANSP).

### *Penitella penita* Conrad

Plates 5, 47-51

*Pholas penita* Conrad 1837, Journal Academy Natural Sciences Philadelphia 7, p. 237, pl. 18, fig. 7 (San Diego and Santa Barbara, California).

*Pholas concamerata* Deshayes 1839, Revue Zoologique par la Société Cuvérienne, p. 357; Deshayes 1840, Magasin de Zoologie, Guérin-Ménéville (2) 2, pl. 17.

*Penitella spelaea* Conrad 1855, United States Pacific Railroad Exploration and Survey, California. Preliminary Geological Report 8, Appendix, pp. 319 and 326, pl. 5, fig. 43 a-b (San Pedro, California, Recent formation).

*Penitella penita* Conrad, Tryon 1862, Proceedings Academy Natural Sciences Philadelphia 14, p. 215.

*Pholadidea penita* Conrad, Carpenter 1864, Report British Association Advancement of Science for 1863, p. 525.

*Penitella curvata* Tryon 1865, American Journal of Conchology 1, p. 40, pl. 2, figs. 6-8 (Straits of Fuca [Vancouver], W. M. Gabb, collector).

*Pholadidea sagitta* 'Stearns' Dall 1916, Proceedings United States National Museum 52, p. 417 (Monterey, California) [young specimen].

*Distinctive characters.* Callum protruding beyond the beaks. Umbonal reflections broad, thin and very closely appressed their entire length. Mesoplax sharply pointed

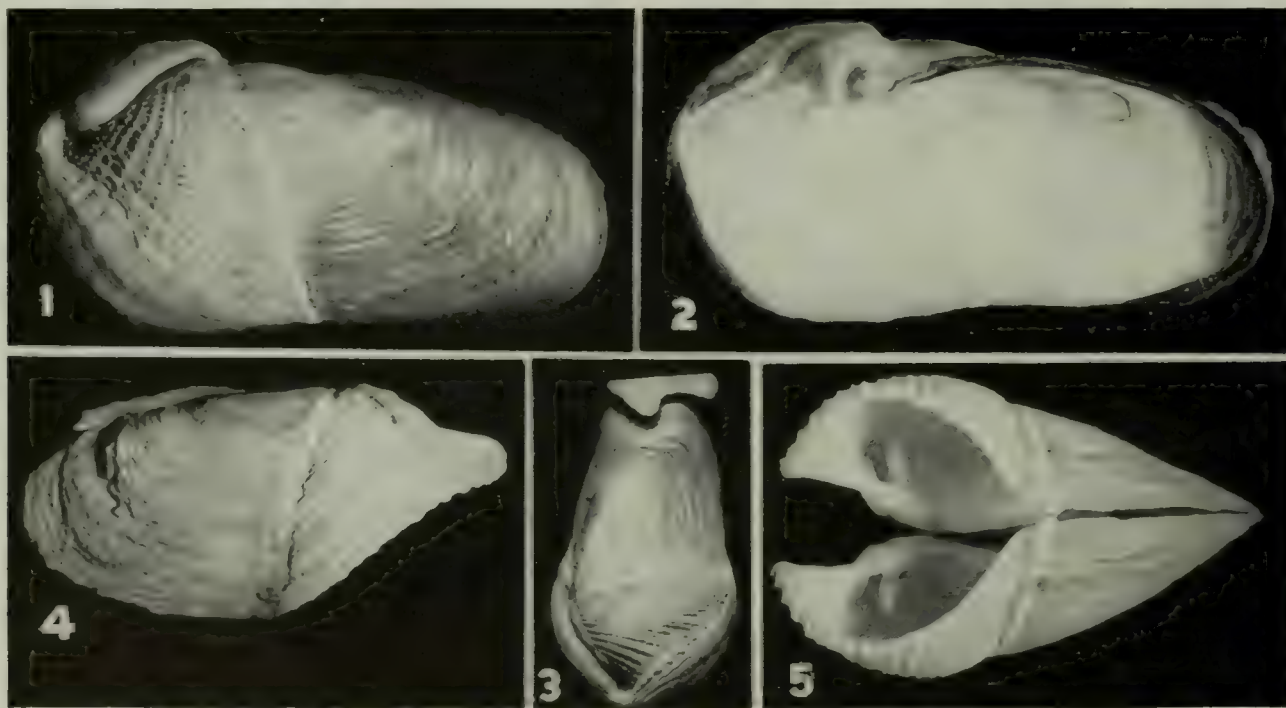


Plate 47. *Penitella penita* Conrad. Figs. 1-2. Anaheim Bay, California. Adult specimen with fully developed callum, siphonoplax missing. Fig. 2. Internal view showing muscle scars and pallial sinus. Fig. 3. Netarts Bay, Tillamook County, Oregon. A small, but adult specimen with fully developed callum and siphonoplax. Figs. 4-5. Monterey Beach, Monterey, California. Young working specimens. Fig. 4. Showing the very closely appressed umbonal reflection. Fig. 5. Ventral view of opposed valves showing the pedal gape and the ventral condyle. (All about natural size.)

posteriorly, truncate anteriorly and having short, pointed, lateral wings. Siphonoplax composed of two heavy, flexible, chitinous flaps which are often diverging. Siphons smooth.

*Description.* Shell medium to rather large in size, reaching 93 mm. (about  $3\frac{3}{4}$  inches) in length and 49 mm. (about 2 inches) in height, oval in outline, solid in structure and producing a callum in the adult stage. Immature specimens beaked and gaping widely anteriorly, tapering slightly posteriorly to a broadly rounded posterior margin which, in adult forms, becomes truncate and terminates in a chitinous flap or siphonoplax. Shell divided into two distinct regions by an umbonal-ventral sulcus. Anterior beaked portion sculptured by close-set, upturned, undulating, concentric ridges and indistinct radial ribs which are indicated largely by the radial arrangement of the undulations. Posterior portion sculptured only by close-set growth lines. Umbos prominent, located near the anterior third of the shell and covered by broad, thin umbonal reflections which are closely appressed their entire length, through which the sculpture of the shell surface can be seen. In adult specimens the pedal gape is closed by a rather heavy callum which extends slightly beyond the beaks and which is sculptured with weak concentric growth lines and faint parallel ridges. A narrow slit remains when the callum is completed and this is covered by a heavy periostracum, with only a minute pore remaining open anteriorly. The callum is extended dorsally over the umbonal reflection and, doubling upon itself, encloses the anterior adductor muscle. Protoplax lacking, being replaced by the dorsal extension of the callum. Mesoplax in young specimens triangular and deeply V-shaped. In adult specimens the dorsal portion of the mesoplax extends anteriorly to form the enclosure for the posterior portion of the anterior adductor muscle. It is usually truncate anteriorly, pointed posteriorly, sharply keeled ventrally and has two small, pointed, lateral wings. Siphonoplax consisting of leathery chitinous flaps which are often widely diverging; they may vary in color from a light yellowish-brown to dark horn color and range in length from 6 to 15 mm. on specimens 65 to 70 mm. long. There are no other accessory plates. Periostracum, particularly on the posterior slope, rather heavy and ranging from a light brown to almost black in color.

Interior of shell white and usually glazed. Umbonal-ventral sulcus evident internally as a low ridge which, in young specimens, extends slightly beyond the ventral margin of the shell forming a condyle. Muscle scars well marked, pallial sinus broad and deep extending inward anterior to the umbonal-ventral ridge. Apophyses rather short, solid, generally flattened at the free end and projecting from beneath the umbos anteriorly at a moderate to sharp angle.



Plate 48. *Penitella penita* Conrad. *Pholas curvata* Tryon (= *P. penita* Conrad) from Straits of Juan de Fuca, Washington. Lectotype ( $5\frac{1}{2}x$ ).

The siphons may be extended about the length of the shell, and they are capable of complete retraction within the shell. Siphons smooth, white for nearly the entire length, but usually marked with a narrow band of dark red-brown reticulations at the posterior extremity. Incurrent siphon with six large and several small branched cirri surrounding the aperture and extending inward as ridges for a short distance. Excurrent siphon with a few very small cirri and few or no internal markings. Foot and mantle white. Foot in immature specimens large, oval in outline and truncate. In adult specimens the foot atrophies and the mantle is closed except for a minute pore at the anterior extremity. The description of the soft parts is based upon preserved material.

The following series of measurements show the variation in the proportion of the length to the height of the shell. All specimens measured had a fully developed callum. The siphonoplax was not included in the measurement of the length as it is so variable and is often broken.

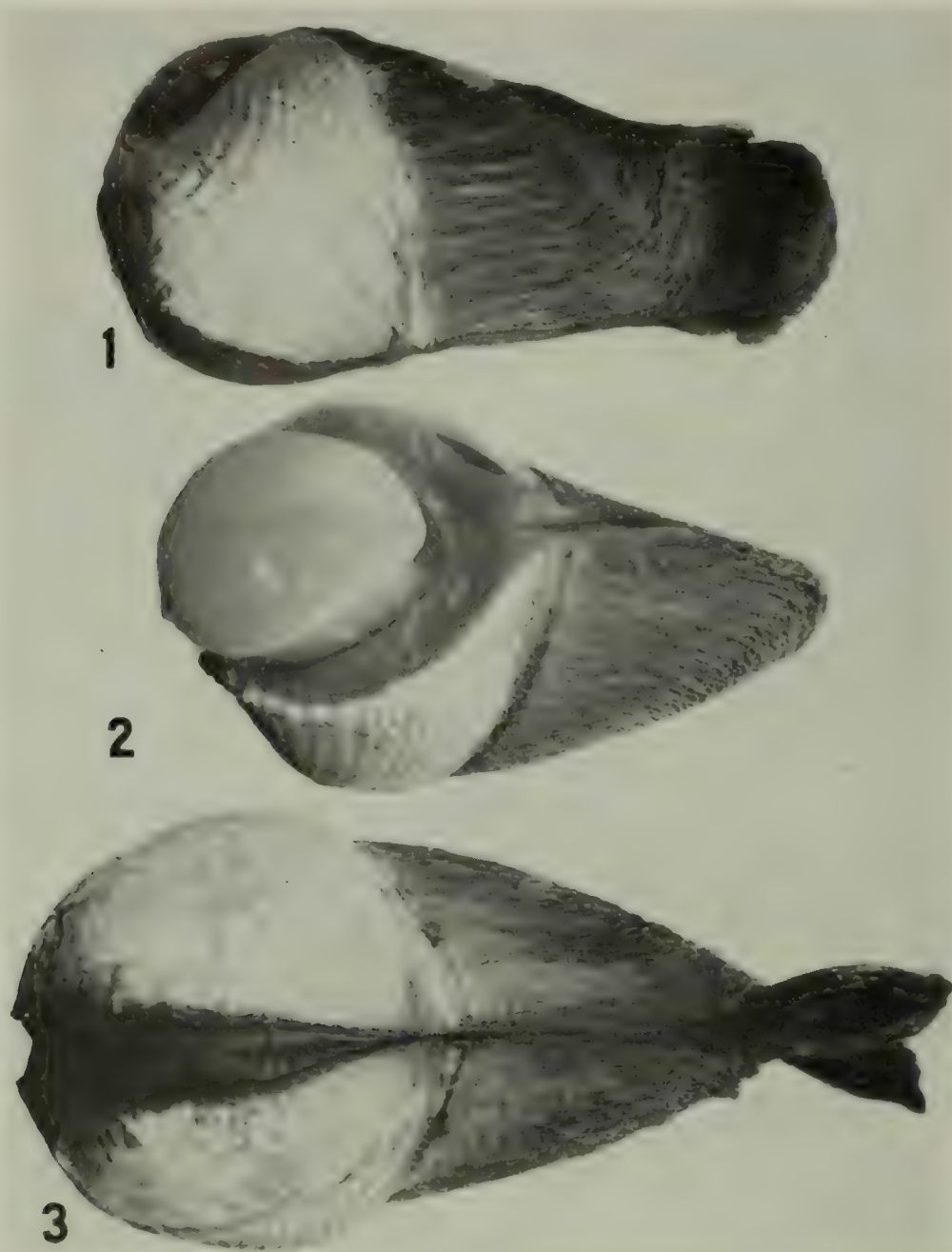


Plate 49. *Penitella penita* Conrad. White Point, San Pedro, California. Figs. 1 and 3. Adult specimens with fully developed callum and siphonoplax. Fig. 2. A young working specimen showing the large, nearly circular foot which atrophies in the adult stage (about 1.8x).

Photographs received through the kindness of J. E. Fitch, California Fisheries Laboratory.

length*	height	ratio h:l	
93.0 mm.	49.0 mm.	1.9	Port Orchard, Oregon
74.5	23.0	3.2	Buhne Point, Humboldt Bay, California
63.4	21.8	2.9	Netarts Bay, Tillamook, Oregon
48.0	27.0	1.8	Anaheim Bay, California
17.0	8.0	2.1	White Point, San Pedro, California
10.0	4.0	2.5	" " " " "

\* All specimens measured had a complete callum.

*Types.* The location of the type specimen of *P. penita* Conrad is unknown. The type locality is San Diego, California. The lectotype of *P. curvata* Tryon is in the Academy of Natural Sciences Philadelphia, no. 51004, from the Straits of Fuca [Vancouver], W.M. Gabb, collector. The location of the type of *Pholas concamerata* Deshayes is unknown; the type locality is California. The holotype of *Pholadidea sagitta* 'Stearns' Dall from Monterey Bay, California is in the United States National Museum, no. 63312.

*Remarks.* This species is one of the most common and best known of the pholads in the Eastern Pacific. In the adult stage it is readily identified by its flexible, leathery siphonoplax, its characteristic mesoplax, and its smooth siphons. Young specimens may

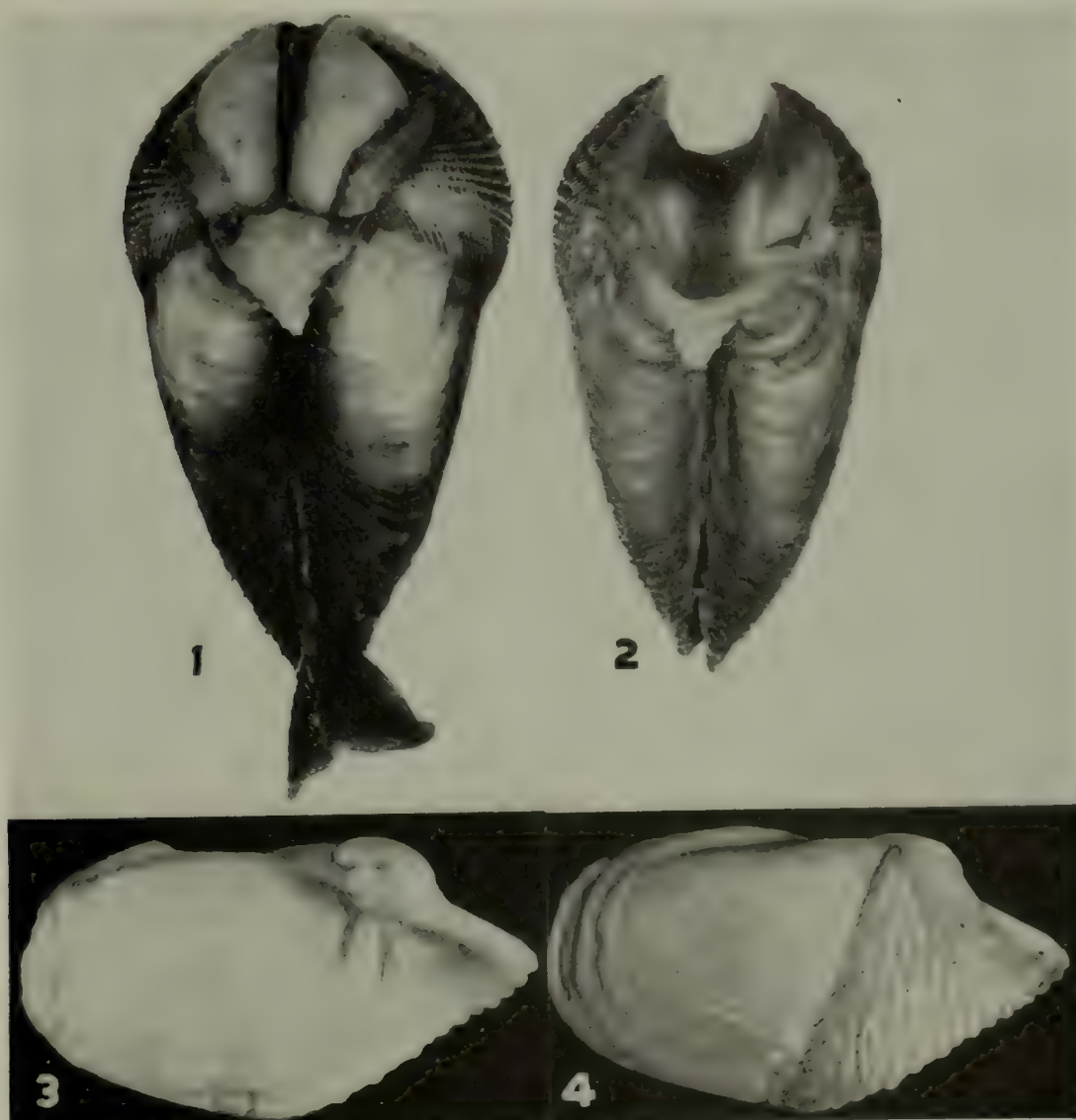


Plate 50. *Penitella penita* Conrad. White Point, San Pedro, California. Fig. 1. Dorsal view of an adult showing the mesoplax which is pointed posteriorly, and the broad umbonal reflection extending on either side of the dorsal extension of the callum (about  $2\frac{1}{2}x$ ). Fig. 2. Dorsal view of young showing the mesoplax. Figs. 3-4. Holotype of *Pholadidea sagitta* Dall (= *P. penita* Conrad), Monterey Bay, California (a young specimen about  $2.3x$ ).

be confused with the young of *P. gabbi* Tryon and of *C. ovoidea* Gould, but can usually be distinguished by the broad, closely appressed umbonal reflection. Specimens of *P. conradi* when boring into soft stone are quite similar to *penita* but the mesoplax of the former species lacks the lateral wings and the siphonoplax is not flexible. See remarks under *P. gabbi* Tryon and *P. conradi* Valenciennes.

There has been considerable confusion as to the identity of *P. sagitta* 'Stearns' Dall, as it was very briefly described and unfortunately was never figured. After examining the type, which we figure, we believe it to be nothing more than a young specimen of *P. penita*.

*Penitella penita* may be found in a variety of substrata ranging from stiff blue clay to sandstone and cement. Specimens are very variable both in size and shape depending upon the amount of crowding and the hardness of the substratum. Examples from Buhne Point, Humboldt Bay, California and some from Netarts Bay, Tillamook, Oregon, are unusually long in proportion to their height, probably showing evidence of rapid growth in an easily worked substratum. Rapidly growing specimens usually have a thin shell with a thin, light colored periostracum and a more fragile callum. Specimens boring into harder rock may become badly distorted especially at the anterior end, and in addition, the shells may be curved and misshapen to fit around obstructions in their burrow. Tryon's *P. curvata* was based on such specimens.

In the final report of the San Francisco Bay Marine Piling Investigation, Kofoed and Miller (1927) stated that *P. penita* Conrad did considerable damage to concrete jacketed piling in San Francisco Bay and Los Angeles Harbor. They also state that *P. penita* Conrad is edible and may be used for food where it occurs in sufficient numbers to justify getting them out of the rocks.

*Range.* From Bering Island, Siberia south at least as far as Bahía San Bartolomé, Baja California.

*Specimens examined:* SIBERIA: Bering Island (USNM). ALASKA: Chirikof Island (USNM); Yakataga Reef, Yakataga District (Hancock Foundation). BRITISH COLUMBIA: Queen Charlotte Islands (USNM); Straits of Juan de Fuca, Vancouver (ANSP; USNM); Victoria (ANSP); Nanaimo (MCZ). WASHINGTON: Neeah Bay (USNM); Port Orchard; South Alki Beach, Seattle (both W. J. Eyerdam); Willapa Bay (E. P.

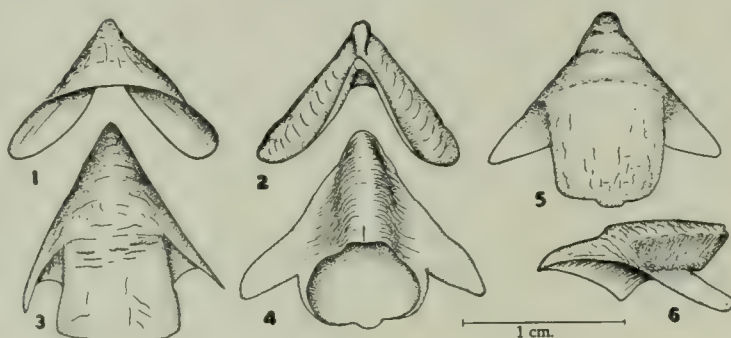


Plate 51. Mesoplax of *Penitella penita* Conrad. Figs. 1-2. Dorsal and ventral views of the mesoplax of a young specimen to show the relationship to *Zirfaea*. Fig. 3. Dorsal view of the mesoplax of an old, worn adult specimen. Fig. 4. Ventral view of the mesoplax of an average adult specimen showing the cavity into which the posterior end of the anterior adductor muscle fits. Fig. 5. Dorsal view of the same specimen to show the dorsal portion which is well inset on the broad base of the young stage forming the lateral wings. Fig. 6. Side view of the mesoplax of an adult specimen. All from specimens collected at Tillamook, Oregon.

Chace; MCZ); Culvers Point, San Juan Island (E. Swan). OREGON: Netarts Bay (R. Coats); Yaquina Bay (MCZ); Newport (MCZ; ANSP; W.J. Eyerdam); Coos Head, Coos Bay (MCZ; USNM); South and Middle Bays, Cape Arago (Hancock Foundation). CALIFORNIA: Crescent City; Half Moon Bay (both MCZ); Pt. Arena; Carmet; Shell Beach; Stewarts Point; Bodega Lagoon; Tomales Bluff (all Hancock Foundation); Monterey Bay (MCZ; USNM; ANSP; Hancock Foundation); Del Monte Beach, Monterey Bay (E. P. Chace); off Del Monte in 12 fathoms (S. S. Berry); San Luis Obispo; Santa Barbara (both MCZ); San Miguel Island (USNM); 1½ miles east of Cardwell Point, San Miguel Island (Hancock Foundation); Carpenteria; White Point, San Pedro (both E. P. Chace and J. E. Fitch); San Pedro (USNM; MCZ; E. P. Chace); Long Beach (MCZ); Buhne Point, Humboldt Bay (J. E. Fitch); Anaheim Bay (MCZ; Hancock Foundation; W.J. Eyerdam); Hazard Canyon, 7 to 8 miles south of Morro Bay (J. E. Fitch); Point Loma (USNM); Portuguese Bend (Hancock Foundation); San Diego (MCZ; ANSP; USNM). MEXICO: Colnett, Baja California (Hancock Foundation); Bahía San Bartolomé, Baja California (J. E. Fitch; USNM).

### *Penitella gabbi* Tryon

Plates 52-54

*Zirfaea gabbi* Tryon 1863, Proceedings Academy Natural Sciences Philadelphia, p. 10, pl. 1, fig. 1 (Coast of Japan?); H. N. Lowe 1931, Nautilus 45, p. 52.

*Pholadidea ovoidea* 'Gould' Oldroyd 1924, Stanford University Publications. Geological Sciences 1, no. 1, pl. 51, fig. 1a-b, not the text or plate 21, figs. 5-6; non *ovoidea* Gould.

*Distinctive characters.* Callum not protruding beyond the beaks. Umbonal reflections narrow, lightly appressed over the umbos and free anteriorly. Mesoplax in the adult specimens with a rounded point posteriorly, pointed anteriorly and with broad lateral wings. Siphonoplax lacking. Siphons pustulose.

*Description.* Shell oval in outline, reaching 55 mm. (2½ inches) in length and 30 mm. (1½ inches) in height, solid in structure and producing a callum in the adult stage. Immature specimens beaked anteriorly and gaping widely, rounded posteriorly and closed. Shell divided into two distinct areas by an umbonal-ventral sulcus. Anterior portion sculptured by close-set, upturned, undulating, concentric ridges and radial ribs. These ribs are indicated largely by the radial arrangement of the undulations and are usually arranged in pairs. Posterior portion sculptured only with concentric growth lines. Umbos prominent and usually located near the anterior third of the shell, however, the post-umbonal length of the shell is rather variable depending upon the speed of growth and the type of substratum in which the animal is boring. Umbonal reflections narrow, free for most of their length and only lightly appressed over the umbos. In adult specimens the pedal gape is closed by a callum which is sculptured with fine concentric growth lines and usually with parallel ridges which indicate a forward extension of the radial ribs. The callum extends dorsally between the beaks, but does not protrude anterior to them or imbed them; it encloses the anterior portion of the anterior adductor muscle. Only a very narrow slit remains when the callum is completed and this is covered by a heavy periostracum with only a minute pore remaining open in the adult. Protoplax lacking, being replaced by the extension of the callum over the umbonal area. Mesoplax trans-

verse and in young specimens deeply V-shaped. In the adult a dorsal portion is added to the mesoplax to enclose the posterior portion of the anterior adductor muscle. This upper portion varies with age from truncate to pointed anteriorly. There are two wide lateral wings on the adult mesoplax. Siphonoplax lacking. Periostracum moderately heavy, a dull grayish-brown to medium brown in color and persistent.

Interior of shell white and usually glazed. Umbonal-ventral sulcus indicated internally as a strong ridge which terminates ventrally in a small condyle. Muscle scars well marked, pallial sinus broad and deep and extending anteriorly to beyond the umbonal-ventral ridge. Apophyses rather short, solid, enlarging slightly at the free end and extending from beneath the umbos anteriorly at a rather sharp angle. Periostracum not extending inside the shell at the siphonal area.

The siphons may be extended 1 to 2 times the length of the shell and may be contracted completely within the shell. They are devoid of periostracum, white in color and strongly pustulose. The pustules are irregular in size and distribution on the siphons and there is no indication of chitinous caps covering the pustules as in *P. ovoidea* Gould. On the specimens studied the pustules appeared to be most abundant near the mid portion, the area near the shell and a small band near the openings being nearly smooth. On occasional specimens there may be faint reticulated markings of a dark mahogany brown at the tip of the siphons. Surrounding the opening the incurrent siphon has 8 to 10 large and several small cirri which extend inside as ridges. Excurrent siphon about one half the diameter of the incurrent siphon, nearly smooth and devoid of all color internally. Mantle and foot white. Foot in young specimens nearly circular in outline and truncate. In adult specimens the mantle is closed except for a minute pore anteriorly and the foot atrophies. The description of the soft parts is based upon preserved material.

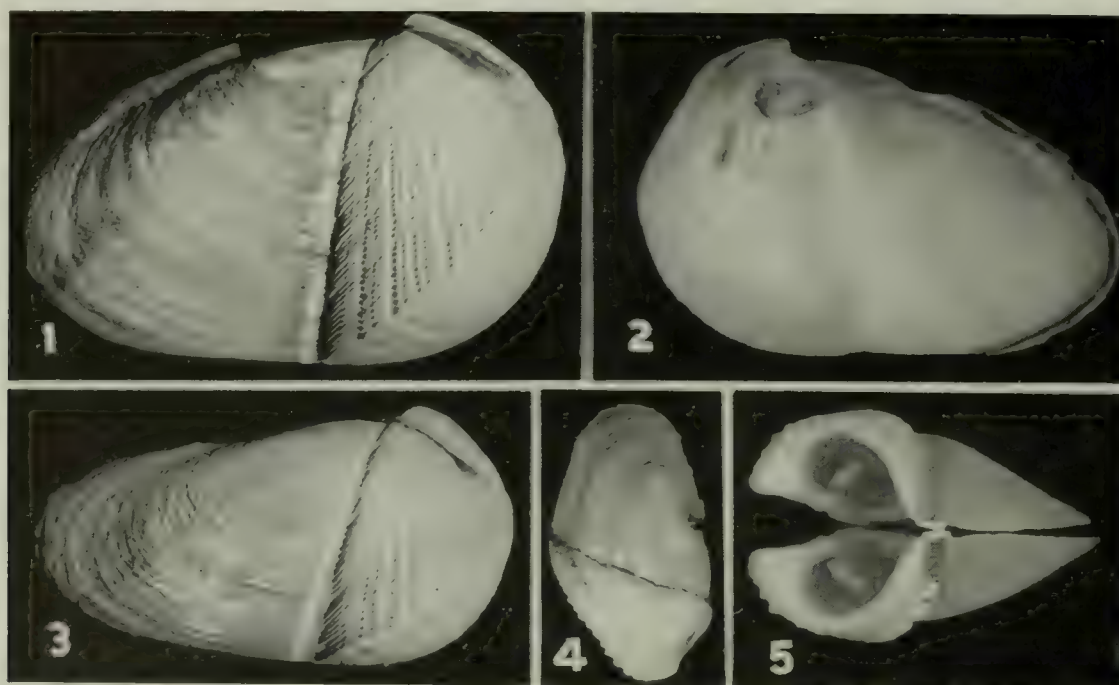


Plate 52. *Penitella gabbi* Tryon. Fig. 1. Restoration Point, Puget Sound, Washington. Figs. 2-5. Del Monte Beach, Monterey Bay, California (all natural size). Fig. 2. Internal view showing the apophysis and muscle scars. Figs. 1 and 3 show the range of length-height proportion, the rounded posterior margin, the cavity beneath the umbonal reflection, and the grouping of the rows of imbrications. Figs. 4 and 5 are young specimens showing the free umbonal reflection and the ventral condyle.

length*	height	ratio h:l	
55.5 mm.	30 mm.	1.8	Holotype of <i>gabbi</i> Tryon
48.0	25	1.9	Del Monte Beach, Monterey Bay, California
32.0	18	1.8	Culvers Point, San Juan Island, Washington
22.0	12	1.8	$\frac{1}{2}$ mile south of White Point, San Pedro, California

\* All specimens measured had a complete callum

*Types.* The holotype of *Zirfaea gabbi* Tryon [= *Penitella gabbi*] is in the Academy of Natural Sciences Philadelphia, no. 51085. In the original description the locality was given as 'Japan?' but the label on the type specimen gives California, W. M. Gabb, collector. The type locality is here restricted to Monterey Bay, California, an area from which we have seen specimens and where Gabb had collected.

*Remarks.* Adult specimens of *P. gabbi* Tryon differ from *P. penita* Conrad, the species with which it is most closely related, by lacking the siphonoplax, by having a more narrowly rounded posterior margin, a shorter, broader mesoplax, and a lighter, thinner periostracum. In addition, the umbonal reflections of *P. gabbi* Tryon are narrow, free anteriorly and only lightly appressed over the umbos, while in *P. penita* they are broad, very closely appressed and almost approach a glaze. In *P. gabbi* the callum is not built forward of the beaks and does not imbed the beaks as it does in most species in this genus. Young specimens of *P. gabbi* and *P. penita* are often difficult to distinguish but the narrow, free umbonal reflections and the more tapering posterior slope of the former can usually be depended upon to separate this species. If the soft parts can be studied the pustulose siphons of *gabbi* quickly distinguish it from *P. penita*.

From *Chaccia ovoidea* Gould this species differs by having a heavier, less inflated shell, a smaller pedal gape and a much more tapering, narrowly rounded posterior slope which is not gaping. In addition, the apophyses of *P. gabbi* project from beneath the umbos anteriorly at a rather sharp angle, whereas in *C. ovoidea* Gould they parallel the umbonal-ventral ridge. The mesoplax in the two species are very different as shown in the plates. In the adult stage *Chaccia ovoidea* Gould is usually much larger and the callum is not completely closed. If the soft parts are available, the large orange chitinous

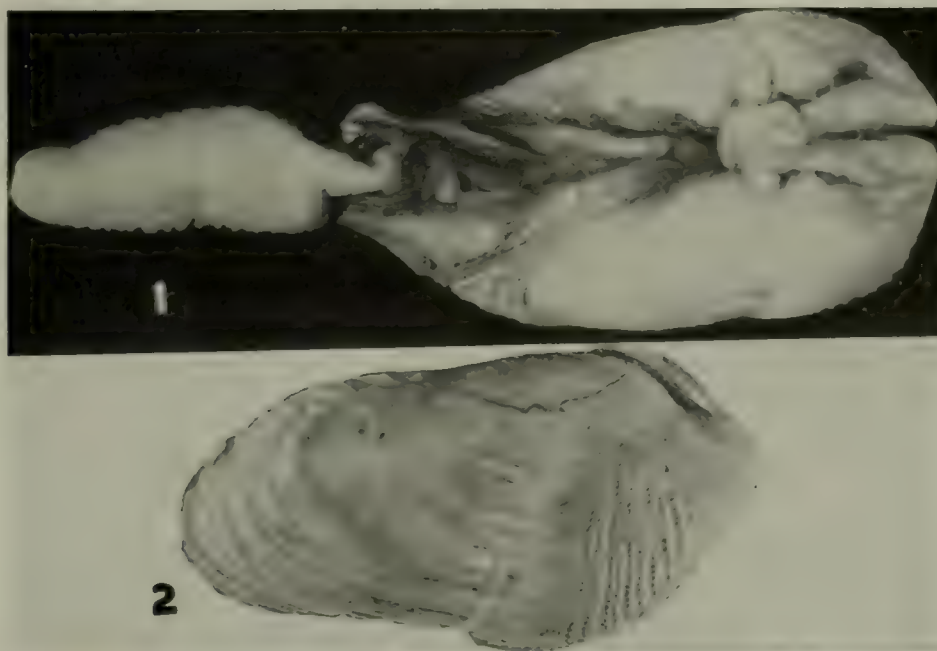


Plate 53. *Penitella gabbi* Tryon. Fig. 1. Culvers Point, San Juan Island, Washington. Preserved specimen showing the pustulose siphons, the broad wings on the mesoplax and the lack of the siphonoplax (about  $1\frac{3}{4}x$ ). Fig. 2. Holotype of *Zirfaea gabbi* Tryon (= *Penitella gabbi* Tryon) (natural size).

patches on the siphons of *C. ovoidea* Gould are in strong contrast to the white, pustulose siphons of *P. gabbi* Tryon.

There has been considerable confusion concerning *Penitella gabbi* Tryon. The name was based on a single mutilated valve from an uncertain locality. On examining the type it was obvious that it was not a *Zirfaea* but the adult of a *Penitella* with the callum broken away. Tryon, not realizing this was a callum-producing form, originally described it as a *Zirfaea*. Lowe later synonymized it with *P. penita* Conrad and many other authors have confused it with *C. ovoidea* Gould. Oldroyd (1924, pl. 51, fig. 1a-b) figures a good specimen of *P. gabbi* Tryon showing the knobby pustulose siphons, but unfortunately under the name of *P. ovoidea* Gould.

The young of *P. gabbi* Tryon are very close in appearance to *Zirfaea constricta* Sowerby, a Japanese species. When more material is available and the life history of *Z. constricta* is known, it may prove to produce a callum when adult: it would then belong in the genus *Penitella* in which case the two species may be the same.

*Penitella gabbi* Tryon is found in the same general habitat as *P. penita* Conrad, but is in general, a much rarer species. This rarity is probably responsible for the apparent gaps in its distribution.

**Range.** From Drier Bay, Alaska south to San Pedro, California.

**Specimens examined.** ALASKA: Drier Bay (W. J. Eyerdam). BRITISH COLUMBIA: Nanaimo (MCZ). WASHINGTON: Tacoma (USNM); Restoration Point, Puget Sound; Port Orchard (both W. J. Eyerdam); Culvers Point, San Juan Island (E. Swan). OREGON: Coos Bay (Hancock Foundation). CALIFORNIA: Bodega Lagoon (Hancock Foundation); Monterey Bay (MCZ); Del Monte Beach, Monterey Bay (E. P. Chace); off Del Monte in 12 fathoms (S. S. Berry); White Point, San Pedro (J. E. Fitch);  $\frac{1}{2}$  mile south of White Point (E. P. Chace); Santa Barbara (MCZ); Hazard Canyon, 7 to 8 miles south of Morro Bay (J. E. Fitch); San Diego (ANSP; Hancock Foundation).

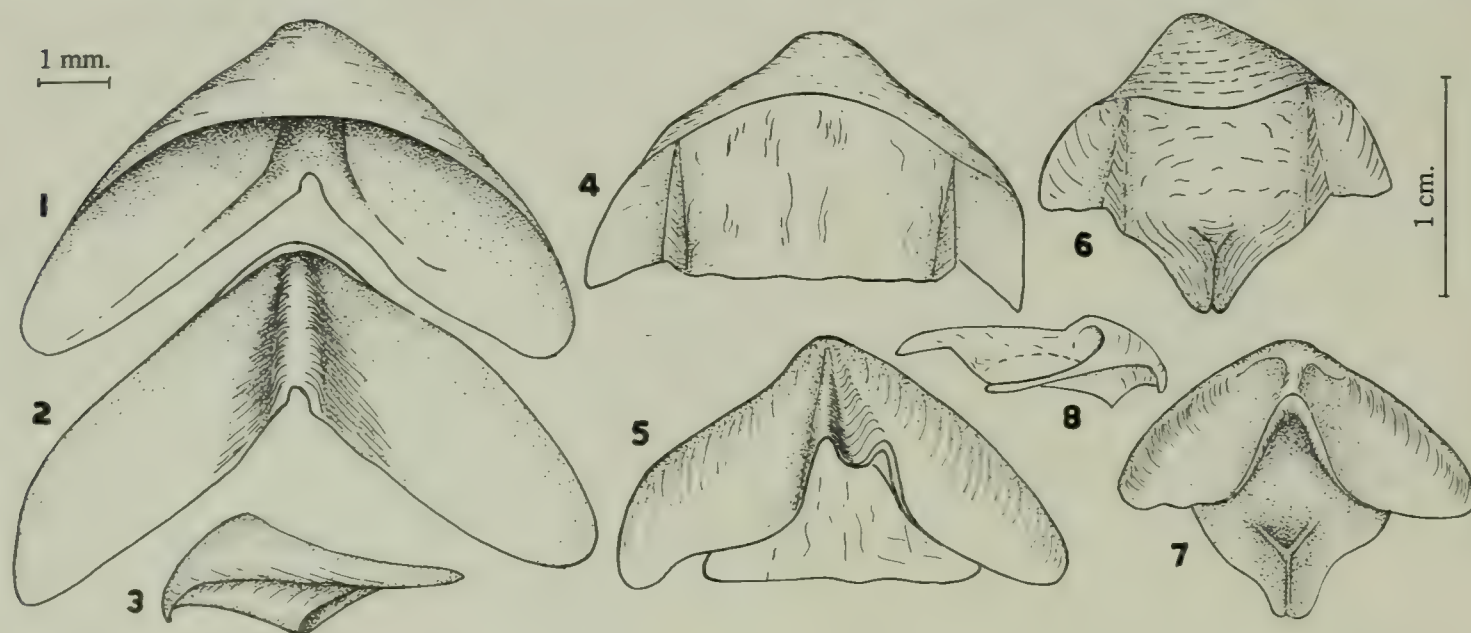


Plate 54. Mesoplax of *Penitella gabbi* Tryon. Fig. 1. Dorsal view of the mesoplax of a young specimen. Fig. 2. Ventral view of the same specimen. Fig. 3. Side view of the same specimen. Fig. 4. Dorsal view of the mesoplax from a specimen that was just beginning to produce a callum showing that at the same time the dorsal portion of the mesoplax is formed. Fig. 5. Ventral view of the same specimen showing a curious deformation of the ventral ridge. Fig. 6. Dorsal view of the mesoplax of an adult specimen to show the pointed anterior end. Fig. 7. Ventral view of the same specimen. Fig. 8. Side view of the same specimen. All figures are from specimens taken at Monterey Bay, California.

Genus *Pholadidea* Turton

*Pholadidea* 'Goodall' Turton 1819, A Conchological Dictionary of the British Islands, London, p. 147.

*Pholadidoidea* de Blainville 1826, Dictionnaire des Sciences Naturelles **39**, p. 535 (genotype, *P. goodall* Turton [= *loscombiana* Turton], monotypic).

*Cadmusia* Leach 1852, A Synopsis of the Mollusca of Great Britain, p. 254 (genotype, *Cadmusia solanderia* Leach [= *loscombiana* Turton] monotypic).

Shells small to moderate in size, more or less oval in outline, divided into two distinct regions by an umbonal-ventral sulcus, and producing a callum in the adult stage. Anteriorly the shell is beaked and widely gaping in the young stage, rounded and closed posteriorly. Umbonal reflections variable. Protoplax lacking, being replaced by a dorsal extension of the callum. Mesoplax small to moderate in size, divided longitudinally into two parts and with the protruding basal portion present or absent. Incipient metaplex and hypoplax present or absent, not existing as separate plates but resulting from the deposition of calcium in the periostracum extending between the valves posterior to the umbos. Siphonoplax largely chitinous and usually fused to form a tube. An additional calcareous siphonal tube is present in some species. Apophyses very small, fragile and not broadening at the free end. Siphons capable of complete retraction within the shell.

Representatives of the genus *Pholadidea* are found in the temperate and tropical portions of all seas other than the Western Atlantic.

Genotype, *Pholadidea loscombiana* Turton, monotypic.

Key to the subgenera of *Pholadidea*

1. Umbonal reflections raised well above the umbos, mesoplax small and lacking a basal portion, siphonoplax cup-like, siphonal tube lacking . . . . . *Pholadidea* s.s.
2. Umbonal reflection closely appressed over the umbos, mesoplax with a basal portion, siphonoplax variable, siphonal tube present . . . . . *Hatasia*

Subgenus *Pholadidea* Turton

*Pholadidea* 'Goodall' Turton 1819, A Conchological Dictionary of the British Islands, London, p. 147.

*Talonella* Gray 1851, Annals and Magazine Natural History (2) **8**, p. 385 (genotype, *Talona tridens* Gray, monotypic).

Shell small to medium in size, oval in outline, divided into two regions by an umbonal-ventral sulcus, strongly beaked and gaping anteriorly in the young stage and producing a callum when adult. Valves rounded posteriorly when young, truncate in the adult stage and terminating with a cup-like siphonoplax. Siphonoplax entirely chitinous or with internal calcareous plates. Siphonal tube lacking. Umbonal reflections free for their entire length. Protoplax lacking. Mesoplax very small and composed of two more or less triangular pieces. Metaplex and hypoplax lacking.

Species in this subgenus, so far as known, are found only in the Eastern Atlantic and the Indo-Pacific. However, a description of the subgenus and of *Pholadidea loscombiana* Turton are included for a complete understanding of the genus.

Subgenotype, *Pholadidea loscombiana* Turton, monotypic.

**Pholadidea (Pholadidea) loscombiana Turton**

## Plates 55-56

*Pholadidea loscombiana* 'Goodall,' Turton 1819, A Conchological Dictionary of the British Islands, p. 147 (Exmouth [England]).

*Pholas papyraceus* Solander 1786, A Catalogue of the Portland Museum, p. 82, lot 1828 [nomen nudum].

*Pholas papyraceus* Turton 1822, Conchyliæ Insularum Britannicarum, p. 2, pl. 1, figs. 1-4 (Torbay [England]).

*Pholas lamellata* Turton 1822, Conchyliæ Insularum Britannicarum, p. 4, pl. 1, figs. 5-6 (Torbay [England]).

*Pholas striata* de Blainville 1825, Manuel de Malacologie, p. 578, pl. 80 [bis] fig. 7; non *Pholas striata* Linné 1758.

*Pholas goodall* [sic] de Blainville 1826, Dictionnaire des Sciences Naturelles 39, p. 532.

*Pholas lamellosus* 'Turton' Sowerby 1834, Proceedings Zoological Society London, p. 69 [error for *lamellata* Turton].

*Pholas vibonensis* Philippi 1844, Enumeratio Molluscorum Siciliæ 2, p. 4, pl. 13, fig. 5 (near Monteleone, Sicily).

*Cadmusia solanderia* Leach 1852, A Synopsis of the Mollusca of Great Britain, p. 254, pl. 11, figs. 1-2.

*Pholadidea papyracea* var. *aborta* Jeffreys 1865, British Conchology 3, p. 117.

*Pholadidea loscombeana* 'Goodall' Lamy 1926, Journal de Conchyliologie 69, p. 138 [error for *loscombiana* Turton].

*Pholadidea solanderiana* 'Leach' Lamy 1926, Journal de Conchyliologie 69, p. 140 [error for *solanderia* Leach].

**Distinctive characters.** Shell reaching about  $1\frac{1}{4}$  inches in length. Umbonal reflections narrow and raised well above the umbos, mesoplax very small and in two parts. Shell truncate posteriorly in the adult stage. Siphonoplax thin, chitinous and with the two parts partially fused to form a tube. There is no siphonal tube.

**Description.** Shell reaching 31 mm. (about  $1\frac{1}{4}$  inches) in length and 17 mm. (about  $\frac{3}{4}$  inch) in height, light in structure and producing a callum in the adult stage. Immature specimens strongly beaked anteriorly and widely gaping, tapering to a rounded, posterior margin. Valves divided into two regions by a narrow umbonal-ventral sulcus. Anterior portion sculptured with concentric ridges and rather weak radial ribs. Rounded imbrications are produced where the concentric ridges and radial ribs cross one another. Posterior portion sculptured by rather strong concentric ridges and growth lines. Umbonal

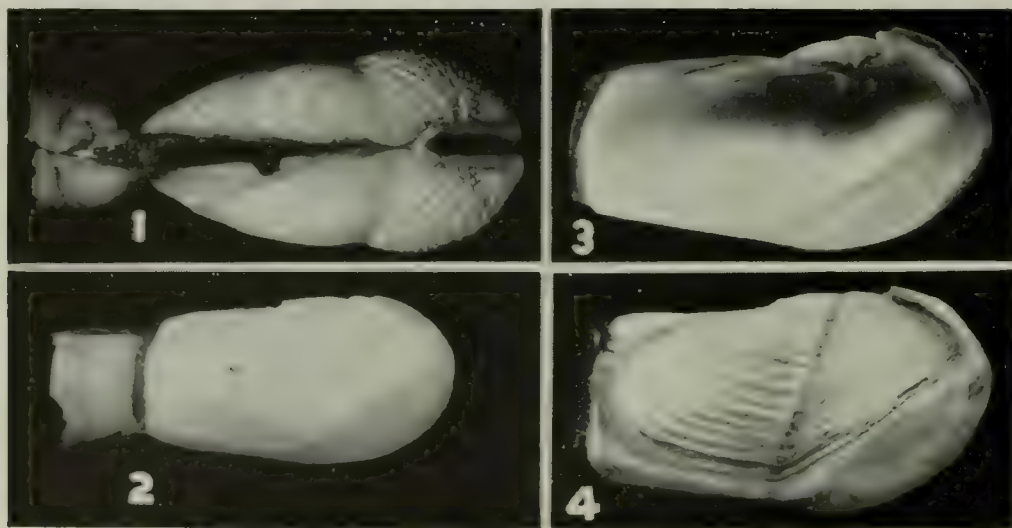


Plate 55. *Pholadidea loscombiana* Turton. English Channel, England. All adult specimens (1.4x). Fig. 1. Dorsal view showing the small mesoplax and the cup-like siphonoplax. Fig. 2. Side view showing the siphonoplax and the truncation of the valve posteriorly in the adult stage. Fig. 3. Inner view of valve showing the small apophysis, the rather large chondrophore and muscle scar. Fig. 4. Side view showing the extent to which the callum may extend anterior to the beaks.

reflections in young specimens simple, narrow and raised well above the surface of the shell. Pedal gape in adult specimens closed by a thin callum which protrudes beyond the beaks and is sculptured by faint growth lines. When the callum is complete only a narrow slit remains between the two halves and this is covered with a heavy periostracum, only a minute pore remaining open. The callum is continued dorsally over the umbonal reflection where it recurves upon itself and encloses the anterior adductor muscle. Protoplax lacking. Mesoplax small and composed of two triangular pieces. Metaplax and hypoplax lacking. Rounded posterior margin of the young specimen becoming truncate in the adult stage, forming the attachment area for the thin, chitinous, cup-like siphonoplax. Periostracum and siphonoplax light straw-yellow in color.

Interior of the shell white and usually glazed. Umbonal-ventral sulcus evident internally as a pronounced ridge. Muscle scars well marked. Pallial sinus broad and deep, extending anteriorly to the umbonal-ventral ridge, but often barely visible. Apophyses small, fragile and projecting anteriorly from beneath the umbos at a sharp angle. A rather large chondrophore is present on the left valve, a smaller one on the right.

Siphons united and capable of extending two to three times the length of the shell. They are a pale to rather dark reddish-brown in color with a narrow band of white at the posterior extremity. Incurrent siphon nearly twice the diameter of the excurrent siphon and fringed with a few large and several small cirri. Exhalant siphon lacking cirri. Just anterior to the siphonal opening there is a ring of white cirri surrounding both siphons. Foot in young specimens more or less oval in outline and truncate, becoming atrophied in the adult. Foot and mantle white. Forbes and Hanley (1853, 1, pl. F, fig. 4) figure in color the siphons of a living specimen.

length *	height	ratio h:l	
34.5 mm.	15.0 mm.	2.3	English Channel, England
30.0	16.0	1.8	" " "
26.0	15.5	1.7	Plymouth, England
23.5	15.0	1.5	" "
21.0	11.0	1.9	" "

\* All specimens measured had a complete callum

*Types.* The holotype of *P. loscombiana* Turton is probably in the British Museum (Natural History). The single specimen on which the name was based was in the Loscombe collection, some of which was later obtained by Sowerby. The location of the types of *P. lamellata* Turton is unknown. According to J. D. Dean (1936, Journ. of Conchology 20, p. 233) the Turton collection was acquired by J. G. Jeffreys and with the Jeffreys collection later went to the United States National Museum. Dr. Rehder, however, informs me that they are not in Washington though a cotype of *P. papyraceus* Turton is there.

*Remarks.* *Pholadidea loscombiana* Turton is the only species in European waters which produces a callum in the adult stage and so is easily recognized. It appears to be most closely related to *Pholadidea tridens* Gray, a New Zealand species, but differs from this latter species by having a thin and entirely chitinous siphonoplax without any internal calcareous plates. The young of *P. loscombiana* have been confused with *Zirfaca crispata* Linné, but differ by having a pronounced umbonal-ventral sulcus and by being closed posteriorly. In addition, the siphons of the two species are very different.

*Pholadidea loscombiana* Turton is restricted in its range to the British Isles and the coast of France probably as far south as northern Spain, but records outside of the British Isles are rare. They bore into mud, clay, peat, waterlogged wood and sandstone and are usually found at low tide level or below, such specimens having been dredged by fishermen off the coast of Ireland. The wide variety of substrata in which this species lives is no doubt responsible for much of the variability of the species and the large number of synonyms noted above.

**Range.** Ireland, southern England, and south along the coast of France to San Sebastian [Spain] (Lamy, 1926, p. 141).

**Specimens examined.** ENGLAND: Torquay (Redpath Museum, McGill University); Plymouth (F. S. Russell); English Channel (MCZ). FRANCE: Cape Breton; Bay of Biscay (both USNM).

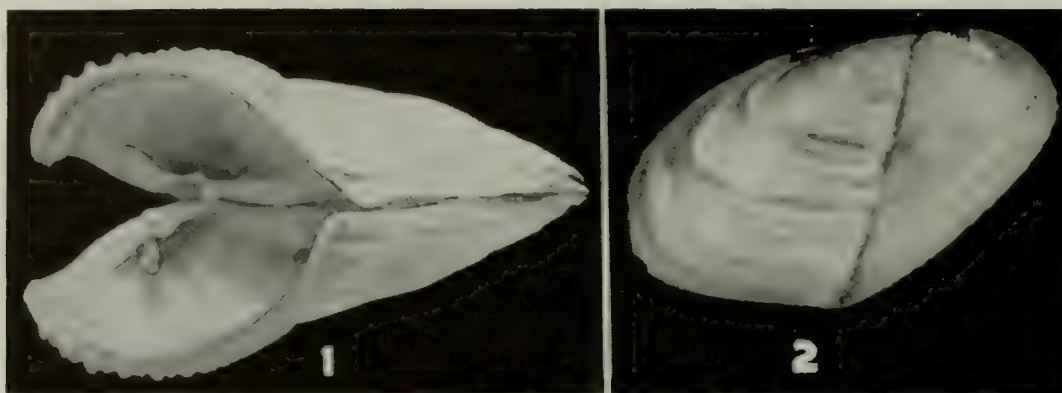


Plate 56. *Pholadidea loscombiana* Turton. English Channel, England. Fig. 1. Young specimen showing pedal gape and hinge area, the apophysis on the left valve is lost but the chondrophore is evident. Apophysis showing on the right valve. Fig. 2. Side view of young specimen to show the high umbonal reflection and the rounded posterior margin (both about 3.3x).

### Subgenus *Hatasia* Gray

*Hatasia* Gray 1851, Annals and Magazine of Natural History (2) 8, p. 385.

Shell small to medium in size, oval to elongate-oval in outline, divided into two regions by an umbonal-ventral sulcus, and producing a callum in the adult stage. Shells strongly beaked and widely gaping anteriorly in the young stage, rounded and closed posteriorly; the siphon being capable of complete retraction within the shell. Siphonoplax chitinous. Siphonal tube calcareous. Protoplax lacking. Mesoplax in the young stage small, flat, more or less semicircular in outline and in one piece. In the adult stage an upper surface is added to the mesoplax covering the posterior portion of the anterior adductor muscle. This upper surface is divided into two parts longitudinally and is usually inset on the young basal portion. Incipient metaplax and hypoplax present or absent.

Subgenotype, *Pholas melanura* Sowerby, subsequent designation, Stoliczka 1870.

### Key to the species of *Hatasia*

1. Siphonoplax tubular with swellings at the base . . . . . 2  
    Siphonoplax diverging, without swellings at the base . . . *tubifera*
2. Posterior portion of valves inflated, shell generally over 28 mm.  
    in length, periostracum and siphonoplax nearly black . . . *melanura*  
    Posterior portion not inflated, shell generally under 20 mm. in  
    length, periostracum and siphonoplax light brown . . . *quadra*

**Pholadidea (Hatasia) melanura Sowerby****Plate 57**

*Pholas melanura* Sowerby 1834, Proceedings Zoological Society London, p. 70 (Montem Christi, Columbiae Occidentalis [Montecristi, Ecuador]).

*Penitella wilsonii* Conrad 1849, Proceedings Academy Natural Sciences Philadelphia 4, p. 156 (Lower California); Conrad 1850, Journal Academy Natural Sciences Philadelphia (2) 1, p. 279, pl. 39, fig. 4 (not fig. 5 as given in the text); Conrad 1854, Journal Academy Natural Sciences Philadelphia (2) 2, p. 335.

*Pholadidea (Hatasia) melanura* Sowerby, Gray 1851, Annals and Magazine Natural History (2) 8, p. 385.

*Pholadidea melanura* Sowerby, Carpenter 1855, Reigen Collection of Mazatlan Mollusca, p. 8; P. Fischer 1858, Journal de Conchyliologie 7, p. 51; Fischer 1860, ibid. 8, p. 5, pl. 3, figs. 1-8.

**Distinctive characters.** Shell reaching about  $2\frac{1}{4}$  inches in length. Posterior slope inflated. Basal portion of the siphonoplax with subreniform swellings, siphonoplax tubular. Siphonal tube generally not firmly attached to the siphonoplax. Periostracum and siphonoplax nearly black.

**Description.** Shell reaching 56 mm. ( $2\frac{1}{4}$  inches) in length and 28 mm. (about 1 inch) in height, thin, inflated, oval in outline and producing a callum in the adult stage. Immature specimens beaked and widely gaping anteriorly, rounded and closed posteriorly. Shell divided into two distinct regions by a pronounced umbonal-ventral sulcus. Anterior portion sculptured with close-set, upturned, undulating ridges and radial ribs. Posterior portion inflated and sculptured with rather strong concentric ridges. Umbos prominent and located near the center of the dorsal margin. Umbonal reflections thin, simple, and closely applied or raised just slightly above the surface of the umbos. Pedal gape in the adult closed by a thin callum which protrudes anteriorly beyond the beaks and extends dorsally over the umbonal reflections to enclose the anterior portion of the anterior adductor muscle. The callum is marked with faint growth lines and weak parallel ridges. Mesoplax in young specimens thin, nearly flat, largely chitinous and semicircular in outline. The dorsal portion of the mesoplax is much narrower than the young basal portion



Plate 57. *Pholadidea melanura* Sowerby. Fig. 1. Panama Bay, 1 mile off the canal entrance in 10 fathoms. Internal view of shell showing the small apophysis. Figs. 2-3. *Penitella wilsoni* Conr. (= *Pholadidea melanura* Sowerby) Baja California. Fig. 2. Paratype, dorsal view showing the mesoplax with its large basal portion. Fig. 3. Lectotype, lateral view showing the high umbonal reflection and the swelling at the base of the siphonoplax (all natural size).

and is divided into two parts longitudinally. An incipient metaplast is formed by the impregnation with calcium of the periostracum between the valves. Siphonoplax consisting of a dark brown to nearly black chitinous tube. Adjacent to the valves there are two subreniform swellings which fuse together to form the extended tubular siphonoplax. Periostracum dark brown to black. Interior of shell white and usually glazed. Umbonal-ventral sulcus evident internally as a strong, beaded ridge. Muscle scars well marked, pallial sinus broad and deep, extending anteriorly beyond the umbonal-ventral ridge and, in some specimens, nearly to the anterior margin of the shell. Apophyses small, solid, slightly grooved at the free end and extending anteriorly from beneath the umbos at a sharp angle.

We have not seen the soft parts of this species, but Fischer (1860, op. cit.) has figured a specimen which he received from Panama.

length*	height	ratio h:l	
56.0 mm.	28.0	2.0	Lectotype, <i>P. wilsonii</i> Conrad
55.5	28.5	1.9	Paratype, " "
52.0	28.0	1.8	Panama Bay
48.0	26.0	1.8	" "
30.0	15.0	2.0	Paratype, <i>P. wilsonii</i> Conrad
28.0	6.5	4.0	" " "

\* All specimens measured had a complete callum

*Types.* The holotype of *Pholas melanura* Sowerby is in the British Museum according to a letter from G. L. Wilkins. The type locality is Monte Cristi, West Columbia [Montecristi, Ecuador]. The lectotype of *Penitella wilsonii* Conrad is in the Academy of Natural Sciences Philadelphia, no. 51012, from Baja California, Dr. Thomas B. Wilson collector.

*Remarks.* *Pholadidea melanura* Sowerby is a very distinctive species, readily differentiated from all others in this group by its nearly black periostracum and siphonoplax, and by its inflated posterior portion. From *Pholadidea quadra* Sowerby, the species with which it is most closely related, it differs by being much larger, having a much heavier, darker periostracum and a larger siphonoplax.

This species is apparently rare and restricted in its distribution. We have seen only five lots and two were from the same locality. The specimens collected by W. D. Clarke off Panama were in 10 fathoms and it may well be that this species occurs abundantly at such depths. However, as they are deep borers they seldom are brought up in dredges and the shells remain *in situ* when the animal dies so that beach specimens are practically unknown.

*Range.* From Baja California south to Ecuador.

*Specimens examined.* MEXICO: Baja California (ANSP). PANAMA: Puerto Armuelles; Guánico (both A. A. Olsson); Panama Bay, 1 mile off the Canal entrance in 10 fathoms (W. D. Clarke). ECUADOR: San Pedro, near Manglalaralto (A. A. Olsson).

**Pholadidea (Hatasia) quadra Sowerby**

## Plate 58

*Pholas quadra* Sowerby 1834, Proceedings Zoological Society London, p. 71 (Montem Christi, Columbiae Occidentalis [Montecristi, Ecuador]); Sowerby 1849, Thesaurus Conchyliorum 2, pt. 10, p. 499, pl. 106, figs. 62-63.

*Pholadidea (Hatasia) quadra* Sowerby, Gray 1851, Annals Magazine Natural History (2) 8, p. 385.

**Distinctive characters.** Shell generally under 1 inch in length, oval in outline. Posterior slope not inflated. Basal portion of siphonoplax with small oval swellings, siphonoplax tubular, siphonal tube not firmly attached to the siphonoplax. Periostracum light brown in color.

**Description.** Shell white, thin, fragile, broadly oval to quadrate in outline, reaching 19 mm. ( $\frac{3}{4}$  inch) in length and 10 mm. (about  $\frac{1}{2}$  inch) in height and producing a callum in the adult stage. Shell strongly beaked and widely gaping anteriorly in the young stage, broadly rounded and closed posteriorly. Valves divided into two regions by a narrow and only slightly impressed umbonal-ventral sulcus. Anterior portion sculptured with concentric ridges and radial ribs, the ribs being expressed mainly by the radial arrangement of the rows of imbrications. Posterior slope sculptured with weak concentric ridges and faint growth lines. Umbonal reflections thin, simple, rather wide and very closely appressed so that the sculpture below may show through. Pedal gape in adult specimens closed by a large, thin callum which protrudes anteriorly well beyond the beaks. It is sculptured with fine concentric growth lines and weak parallel ridges which are extensions of the radial ribs. The callum extends dorsally over the umbonal reflection and encloses the anterior adductor muscle. Mesoplax unknown except as figured by Sowerby. It is more or less rectangular in outline with a wide basal portion and the upper part divided

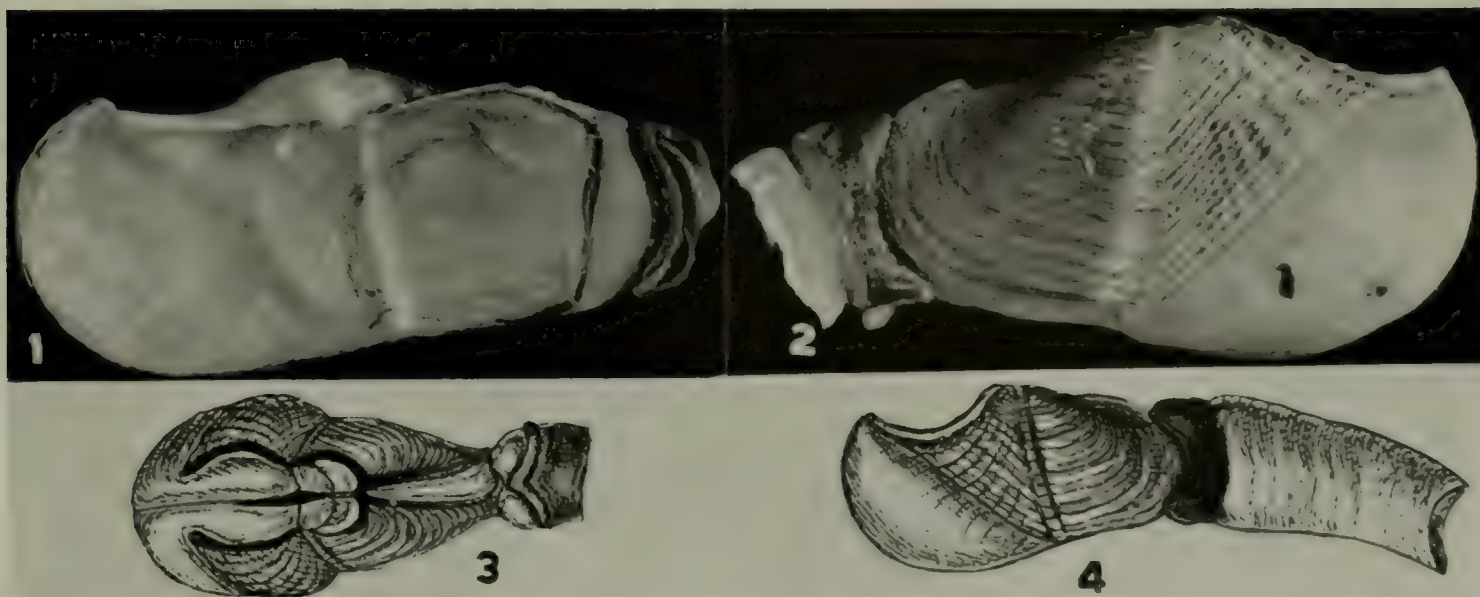


Plate 58. *Pholadidea quadra* Sowerby. Figs. 1-2. Ecuador (about 3x). Fig. 1. Interior view of adult showing the minute apophysis, the pronounced muscle scars and the pallial sinus. Fig. 2. External view showing the greatly produced callum, the siphonoplax and the beginning of the siphonal tube. Figs. 3-4. Copies of the figure from Sowerby, Thesaurus Conchyliorum 2, pl. 106, figs. 62-63 (2.2x). Fig. 3. Dorsal view showing the divided mesoplax with its large basal area, the dorsal extension of the callum and the siphonoplax. Fig. 4. Side view showing the siphonal tube. The dorsal extension of the callum is lacking in both figures 2 and 4.

longitudinally into two parts. Metaplast and hypoplast lacking. Siphonoplast chitinous, light brown in color, and with swellings near the base. Siphonal tube calcareous, thin and firmly attached. Periostracum thin, a light red-brown in color and persistent. Interior of shell white and glazed. Umbonal-ventral sulcus evident internally as a beaded rib. Muscle scars well marked. Pallial sinus broad and deep, extending anteriorly to beyond the umbonal-ventral rib. Both concentric and radial sculpture visible internally. Apophyses very small, solid, and extending from beneath the umbo anteriorly at a rather sharp angle.

The soft parts of this species are unknown.

length	height	ratio h:l	
19 mm.	10 mm.	1.9	Ecuador

*Types.* The location of the types of *Pholas quadra* is unknown. They are not in the British Museum according to a letter received from G. L. Wilkins. A possible cotype is in the P. P. Carpenter collection in the Redpath Museum. The type locality is Monte Christi, West Columbia [Montecristi, Ecuador].

*Remarks.* We know practically nothing concerning *Pholadidea quadra* Sowerby, except that it does exist. It was originally collected by Hugh Cuming in loose sand and clay at Montecristi, Ecuador. It is most closely related to *P. melanura* Sowerby from which it differs by being much smaller, having a less inflated posterior portion, and a light brown rather than nearly black periostracum. From *P. tubifera* it differs by having a tubular, rather than diverging, siphonoplast, and in having swellings at the base of the siphonoplast.

*Range.* Known only from Ecuador.

*Specimens examined.* ECUADOR: (MCZ; Redpath Museum): Crucita, east of Manta (A. A. Olsson).

### **Pholadidea (Hatasia) tubifera Sowerby** Plate 59

*Pholas tubifera* Sowerby 1834, Proceedings Zoological Society London, p. 71 (Sinum Caraccensem, Columbiae Occidentalis [Bahía de Caragues, Ecuador]).

*Pholas tubifer* Sowerby 1849, Thesaurus Conchyliorum 2, pt. 10, p. 499, pl. 106, figs. 64-65; Sowerby 1849, Proceedings Zoological Society London, p. 162, pl. 5, fig. 5 [error for *tubifera* Sowerby].

*Pholadidea (Hatasia) tubifera* Sowerby, Gray 1851, Annals Magazine Natural History (2) 8, p. 385.

*Pholadidea tubifera* Sowerby, H. and A. Adams 1865, Genera of Recent Mollusca 2, p. 329; Fischer 1853, Journal de Conchyliologie 7, p. 243; Dall 1909, Proc. United States National Museum 37, no. 1704, p. 277.

*Distinctive characters.* Shell reaching about  $1\frac{1}{2}$  inches in length and elongate-oval in outline. Basal portion of the siphonoplast diverging, siphonal tube heavy, calcareous and firmly attached to the siphonoplast.

*Description.* Shell elongate-oval in outline, reaching 37.5 mm. (about  $1\frac{1}{2}$  inches) in length and 14 mm. (about  $\frac{1}{2}$  inch) in height, solid in structure and producing a callum in the adult stage. Immature specimens beaked anteriorly and widely gaping; narrowly rounded posteriorly and closed. Shell divided into two regions by a narrow and often

weak umbonal-ventral sulcus. Anterior portion sculptured with very close-set, laminated undulating ridges and radial ribs. The radial ribs are expressed only by the radial arrangement of the undulations and the thickening of the ridges where the ribs cross. Umbonal reflections simple, narrow and usually appressed. Pedal gape in adult specimens closed by a rather heavy, protruding callum which extends anteriorly well beyond the beaks. The callum continues dorsally over the umbonal reflection and forms the enclosure for the anterior portion of the anterior adductor muscle. Mesoplax in young specimens unknown. In adult specimens it is more or less square to rectangular in outline and divided into two parts longitudinally. Metaplax and hypoplax lacking. Siphonoplax composed of diverging, chitinous flaps with a heavy fold posteriorly which unites the two parts and forms the base to which the long calcareous siphonal tube is attached. Periostracum thin, light brown in color and persistent.

Interior of shell white and usually glazed. Umbonal-ventral sulcus evident internally as a rib. Muscle scars well marked. Pallial sinus broad and deep, extending anteriorly to just beyond the umbonal-ventral ridge. Concentric sculpture clearly visible internally. Apophyses very small and weak, and extending from beneath the umbo anteriorly at a rather sharp angle.

We have not seen the soft parts of this species, but Fischer (1858, *Journal de Conchyliologie* 7, p. 247) gives a description of specimens which he received from Panama.

length	height	ratio h:l	
37.5 mm.	14.0 mm.	2.6	Panama City, Panama
22.0	11.0	2.0	Panama
22.0	10.0	2.2	"
20.0	8.0	2.5	"
15.0	8.5	1.7	"

*Types.* The types of *Pholas tubifera* Sowerby are in the British Museum (Natural History) according to a letter received from G. L. Wilkins. The type locality is Bahía de Caráques, Ecuador.

*Remarks.* *Pholadidea tubifera* Sowerby is not closely related to any species of *Pholadidea* in the Eastern Pacific. It approaches *P. quadra* in size, but is generally a much

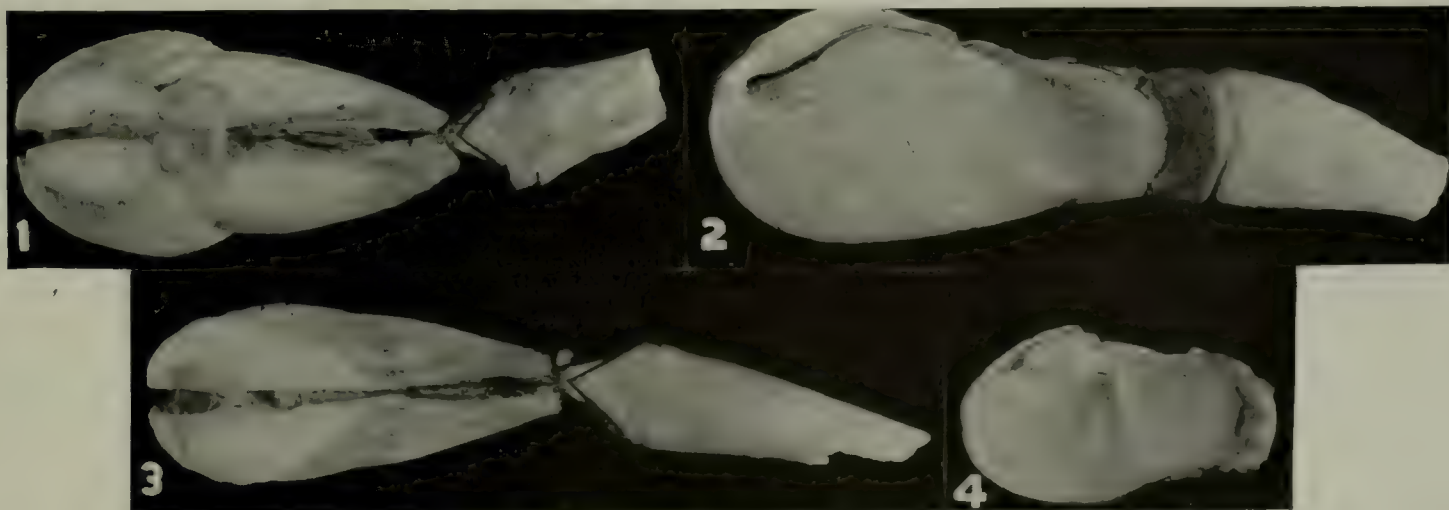


Plate 59. *Pholadidea tubifera* Sowerby. Panama. Fig. 1. Dorsal view showing the divided mesoplax, diverging siphonoplax and siphonal tube. Fig. 2. Side view showing protruded callum. Fig. 3. Ventral view. Fig. 4. Internal view of valve to show the umbonal-ventral ridge, muscle scars and pallial sinus (all about 2x).

heavier shell, has a diverging rather than tubular siphonoplax and a heavy siphonal tube. See also remarks under *P. quadra* Sowerby.

Little is known concerning this species. Sowerby states in the original description that Hugh Cuming obtained the specimens from a piece of decayed wood dredged in 10 fathoms. Dr. Olsson writes that the specimen collected at Esmeraldas, Ecuador were in shale. The *Hassler* obtained several fine specimens from off Panama and it may well be that in certain restricted areas they are abundant.

*Range.* Panama south to Payta, Peru (Dall 1909).

*Specimens examined.* PANAMA: Balboa, Canal Zone; Panama City (both J. Zetek); off Panama (*Hassler* Voyage). ECUADOR: Esmeraldas (A. A. Olsson).

### Genus *Lignopholas*, new genus<sup>1</sup>

Species in this genus are small wood borers. They are elongate-oval to pear-shape in outline, the valves are divided into two distinct areas by an umbonal-ventral sulcus and a callum is produced in the adult stage. Shells beaked and widely gaping anteriorly in the young stage; the beaks being truncated give the shell a teredo-like appearance. Valves narrowly rounded and closed posteriorly. Posterior slope covered by a series of overlapping, thin, chitinous lamellae which are fringed on their posterior margin. Umbos prominent and located near the center of the dorsal margin in young shells, but in the adults they are very near the anterior end due to the disproportionate growth of the posterior slope. Mesoplax divided longitudinally; all other accessory plates lacking. Sulcus expressed internally as a pronounced umbonal-ventral ridge. Apophyses very long, thin, and fragile. There is a pronounced chondrophore in the left valve and an internal ligament.

The species in this genus superficially resemble *Martesia*, particularly in the young stage. They have the funnel-shaped pit below the umbonal reflection and a similarly shaped pedal gape. However, the adults are readily distinguished by the lack of both the meta-plax and the hypoplax, and in addition, by the presence of the chitinous lamellae on the posterior slope.

There are only two known species in this genus. One, *L. rivicola* Sowerby is a fresh-water species recorded only from Borneo; the other, *L. clappi* Turner, is known only from Bluefields, Nicaragua, where it occurs in brackish water. Both species appear to bore into wood near the surface of the water rather than at the mud line as do most pholads. It is impossible at this time to explain the distribution of these two closely related species.

Little is known concerning the destructiveness of *L. rivicola* Sowerby, but it is recorded as boring into floating timbers of the landing pier at Gunung Tebur, Borneo. At Bluefields, Nicaragua, *L. clappi* appeared to be rather destructive during the period that test boards were submerged there.

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<sup>1</sup> From the Latin *lignum* (wood) and *pholas*.

**Lignopholas clappi**, new species<sup>1</sup>

## Plate 60

*Distinctive characters.* A small wood borer superficially resembling a *Martesia*, but lacking the metaplast and hypoplast, and having the mesoplast divided longitudinally into two parts. In addition, there is a series of overlapping chitinous lamellae on the posterior slope.

*Description.* Shells variable in size and shape, the larger specimens reaching about 25 mm. (1 inch) in length and about 6 mm. ( $\frac{1}{4}$  inch) in height. Specimens generally a slender pear-shape in outline, white to light brown in color and having a callum in the adult stage. Young specimens are beaked and widely gaping anteriorly; the beaks being truncated, give the shell a teredo-like appearance. Posteriorly the shell tapers to a rounded margin which may be broad or narrow depending largely upon the age of the specimen. Valves divided into two distinct regions by an umbonal-ventral sulcus. Anterior portion sculptured by close-set denticulated ridges. Posterior portion sculptured with smooth, rounded, concentric ridges which are continuations of the denticulated ridges of the anterior slope. In addition, the posterior portion has a series of overlapping chitinous lamellae which are coarsely fringed. An adult specimen may have six to eight of these lamellae. Umbos prominent, located near the center of the dorsal margin in young specimens, but in adults, very close to the anterior end due to the disproportionate growth of the

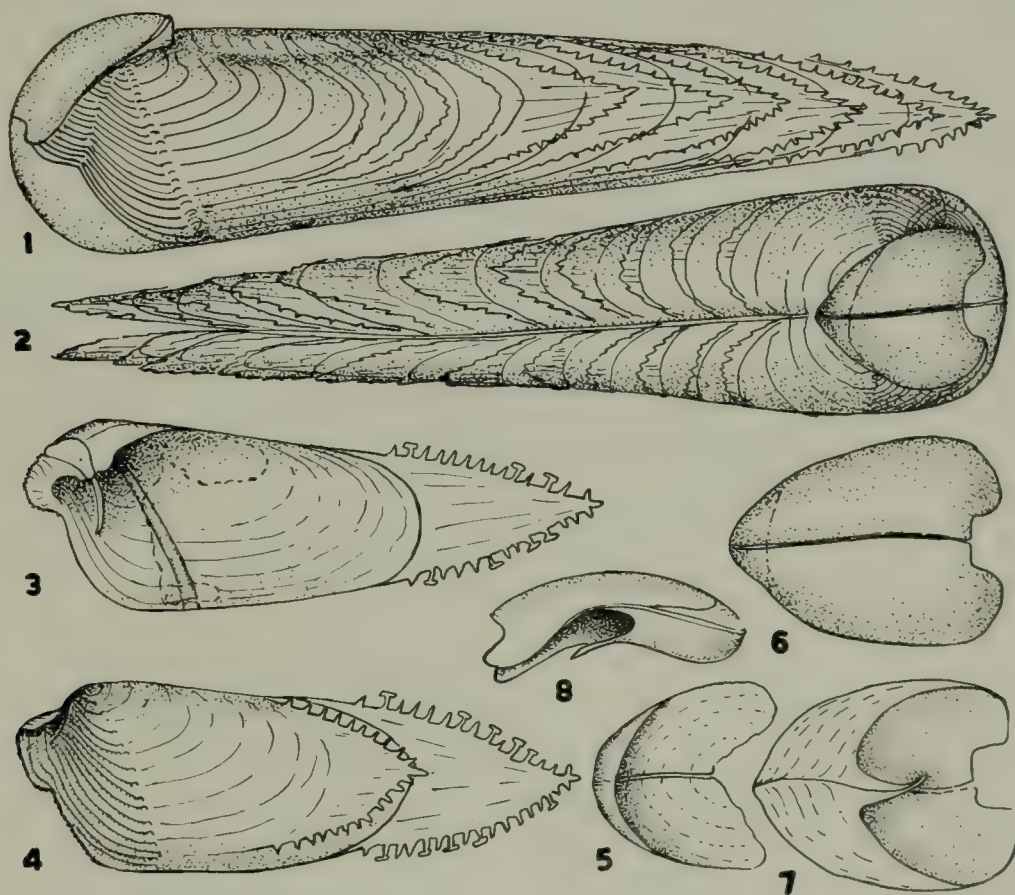


Plate 60. *Lignopholas clappi* Turner. Fig. 1. Side view of the holotype showing the extent to which the mesoplast extends over the beaks and the chitinous lamellae on the posterior slope. Fig. 2. Dorsal view of a paratype to show the divided mesoplast and the lack of the metaplast. Fig. 3. Internal view of a young specimen. Fig. 4. External view of a young specimen. Fig. 5. Dorsal view of the mesoplast of a young specimen. Fig. 6. Dorsal view of the mesoplast of an adult specimen. Fig. 7. Ventral view. Fig. 8. Side view. All from Bluefields, Nicaragua. Figs. 1-2 (4x); Figs. 3-8 (6x).

<sup>1</sup> Named for the late Dr. William F. Clapp, of the Clapp Laboratories, Duxbury, Massachusetts.

posterior portion. Umbonal reflections rather small, thin and closely appressed over the umbos. A rather heavy callus extends over the umbo where the anterior adductor muscle is attached. In adult specimens the pedal gape is closed by a thin, smooth callum which does not extend dorsally between or over the beaks. The two halves of the completed callum are connected by a thin periostracum, only a minute pore remaining open in the fully adult specimen. Protoplax lacking. Mesoplax in young specimens more or less semicircular in outline with a median groove and faint concentric growth lines. In the adult, the dorsal portion of the mesoplax grows forward, completely covering the anterior adductor muscle and extending over the beaks. Interior of the shell white and glazed. Muscle scars only faintly indicated, the large oval posterior adductor muscle scar set high on the posterior slope. Pallial sinus extending anteriorly to the umbonal-ventral ridge. Periostracum thin, light straw-yellow and persistent. The soft parts of this species are unknown.

length*	height	ratio h:l	
24.2 mm.	7.0 mm.	3.4	Holotype
18.0	6.3	2.8	Paratype
12.8	5.4	2.3	"
15.0	3.8	3.9	"
5.0	2.8	1.7	"

\* All specimens measured had a complete callum

*Types.* Holotype, Museum of Comparative Zoölogy, no. 200,046 from Bluefields, Nicaragua. Paratypes from the same locality are in the collection of the Museum of Comparative Zoölogy and the United States National Museum.

*Remarks.* This is a very distinctive species most closely related to *L. rivicola* Sowerby from freshwater at Gunung Taboor [Gunung Tebur], twelve miles up the Pantai River in Borneo, a species collected during the voyage of the *Samarang*. *Lignopholas clappi* is a smaller, more slender species with a much finer fringe on the chitinous lamellae and in addition, the mesoplax of *clappi* is pointed posteriorly rather than truncate. It is a wood borer and is found in both brackish and marine conditions. Of our American species, *L. clappi* superficially appears close to species of *Martesia*, but it lacks both the metaplast and the hypoplast, and in addition, has chitinous lamellae on the posterior slope, a condition not found in *Martesia*.

Specimens of this species were taken from test boards suspended from the wharf in Bluefields Lagoon at a depth of eighteen inches below the surface. At this station the water was brackish and sluggish. The board was submerged under the supervision of the W. F. Clapp Laboratories, Duxbury, Massachusetts, on June 12, 1935 and removed February 28, 1936. A second test board was submerged at Schooner Cay, Bluefields, Nicaragua, on December 27, 1935 and removed April 10, 1936. At this locality the water though still a little brackish was far more affected by the tides. Young and adult specimens were taken from both boards which would indicate that breeding probably occurs throughout the year.

It is curious, that despite all the collecting and test board studies which have been made along the Central American coast, this species has been taken only in this one area.

It is apparently abundant at Bluefields, judging from the numbers that occurred in the test boards.

*Range.* Known only from the type locality.

*Specimens examined.* NICARAGUA: Schooner Cay and Bluefields Lagoon, Bluefields (MCZ; USNM).

### Genus *Martesia* Sowerby

*Martesia* 'Leach' Sowerby 1824, Genera of Recent and Fossil Shells, part 23, *Pholas*, p. 2 (genotype, *Pholas clavata* Lamarck [= *M. striata* Linné], monotypic); de Blainville 1825, Manuel de Malacologie, p. 632. Bartsch and Rehder 1945, Smithsonian Miscellaneous Collections 104, no. 11, p. 2.

*Mactresia* Gray 1840, Synopsis Contents British Museum, ed. 42, p. 154 [error for *Martesia* Sowerby].

*Mactesia* 'Gray' Paetel 1875, Familien-und Gattungsnamen Mollusken, p. 119 [error for *Martesia* Sowerby].

Shells rather small, not reaching over 50 mm. (2 inches) in length, light in structure, white to light ivory in color, generally pear-shaped in outline, divided into two distinct regions by an umbonal-ventral sulcus and producing a callum in the adult stage. Shells beaked and widely gaping anteriorly in the young stage: the beaks sinuously to sharply truncated, giving the shells a teredo-like appearance. Valves narrowly to broadly rounded posteriorly and closed. Siphons capable of complete retraction within the shell. Umbos prominent, nearly centrally located in young shells. In the adult they are very near the anterior end due to the disproportionate growth of the shell. Umbonal reflections closely appressed over the umbos but free anteriorly. They are broadly recurved, forming a funnel-shaped pit below. Protoplax lacking. Mesoplax variable, ranging from circular to cuneiform in outline. Metaplax and hypoplax long, narrow and pointed anteriorly. Posteriorly they may be pointed, truncate or divided. Interior of the shell with a pronounced umbonal-ventral ridge which is enlarged to form a condyle at the ventral margin. Chondrophore and internal ligament present, but small. Apophyses long, thin and fragile.

The genus *Martesia*, like nearly all genera of the Pholadidae, is clear-cut and easily distinguished. It is characterized by the teredo-like shell in the young stage, by the presence of a mesoplax, metaplax and hypoplax, and by the funnel-shaped pit below the umbonal reflection. In addition, the species normally bore only into wood, seeds or other woody substances. The genus is probably most closely related to *Diplothyra*, which has often been considered a subgenus of *Martesia*. See also under *Diplothyra*.

Species of *Martesia* occur throughout the world in nearly all temperate and tropical regions, but their distribution is rather difficult to understand at present. Undoubtedly a thorough knowledge of the life histories of the various species concerned will answer many of the problems. *Martesia striata* Linné, the best known and most widely distributed species in the genus, is the most destructive and has succeeded in invading nearly all tropical and south temperate seas. Whether this ability to spread is due to a wide range of temperature and salinity tolerance or to some factor in the life history of this species, it is impossible to say. However, *Martesia cuneiformis* Say, which is often found living with *M. striata* Linné, is restricted to the Western Atlantic. A third species, *M. fragilis* Verrill and Bush, appears to be a pelagic species, with only occasional specimens being taken from fixed structures.

Two factors complicate the taxonomy of this genus. The first is the great variability within the species. This is an expression of the rate of growth and amount of crowding of the specimens as well as the hardness of the substratum in which they are living. Specimens living in overcrowded conditions may reach maturity and produce a callum when not more than 5 mm. in length. Such specimens are often referred to as stenomorphs, a term more generally used in the Teredinidae. Other specimens with ample room, boring into soft wood such as palmetto, may reach a length of 40 mm. or more before producing a callum. These specimens usually have thin, perfectly formed shells with widely spaced rows of imbrications and a smooth, nearly circular mesoplax. However, equally uncrowded specimens boring into hard, knotted wood usually have closely set rows of imbrications; the shell may be variously curved to fit around obstructions in the burrow, and the mesoplax is often badly deformed. From the large amount of material available for study it is obvious that the number of rows of imbrications cannot be used as a character to distinguish species. The second factor complicating the taxonomy is the great difference between the young and adult specimens. This has resulted in the description of several genera based upon the young stages of the various species. As shown in the diagram (plate 64) the valve of a young specimen is nearly circular in outline with a centrally located umbo. Gradually the posterior portion elongates so that just before the callum is produced the posterior portion may be two and one-half to three times as long as the anterior portion. Usually at the time the callum is produced an unsculptured portion is also added to the posterior end of the valve making it as much as five to six times the length of the anterior portion.

Genotype, *Pholas clavata* Lamarck (= *P. striata* Linné), monotypic.

Two subgenera in the genus *Martesia* may be separated as follows:

1. Mesoplax oval to circular, metaplex and hypoplex pointed or truncate posteriorly, not divided . . . . . *Martesia*
2. Mesoplax wedge-shaped or cuneiform, metaplex and hypoplex divided posteriorly . . . . . *Praticoma*

### Subgenus *Martesia* Sowerby

*Martesia* 'Leach' Sowerby 1824, Genera of Recent and Fossil Shells, part 23, *Pholas*, p. 2 (genotype, *Pholas clavata* Lamarck [= *M. striata* Linné], monotypic); de Blainville 1825, Manuel de Malacologie, p. 632.

*Martesiella* Verrill and Bush 1898, Proceedings United States National Museum 20, no. 1139, p. 777 (subgenotype, *Martesia* (*Martesiella*) *fragilis* Verrill and Bush).

*Hiata* Zetek and McLean 1936, Nautilus 49, p. 110 (genotype, *Hiata infelix* Zetek and McLean [= *M. striata* Linné], original designation).

*Mesopholas* Taki and Habe 1945, Venus 14, p. 109 (genotype, *Mesopholas intusgranosa* Taki and Habe [= *M. striata* Linné], original designation).

*Diploplex* Bartsch and Rehder 1945, Smithsonian Miscellaneous Collections 104, no. 11, p. 10 (subgenotype, *Martesia* (*Diploplex*) *americana* Bartsch and Rehder [= *M. striata* Linné], original designation).

The species in the subgenus *Martesia* are characterized by having the mesoplax broadly oval to circular in outline and having the metaplex and hypoplex pointed or truncate and not divided. In addition, there is a sickle-shaped shield over the umbo which forms the attachment area for the anterior adductor muscle. The shield is attached anteriorly, but free posteriorly, and raised well above the surface of the umbo. The transverse, basal portion of the mesoplax fits beneath the free end of the shield. The beaks are truncated

nearly at right angles to the anterior margin of the disc, giving the shell a teredo-like appearance.

This subgenus is distributed throughout the temperate and tropical regions of the world.

Subgenotype, *Pholas clavata* Lamarck (= *M. striata* Linné), monotypic.

### Key to the American species of *Martesia* ss.

1. Mesoplax of adult specimens more or less circular, inflated and sculptured only by irregular wrinkles . . . . . *M. striata*
2. Mesoplax oval, dorsal portion depressed, with a peripheral keel and definite concentric sculpture . . . . . *M. fragilis*

### *Martesia* (*Martesia*) *striata* Linné

Plates 35: 61–64

*Pholas striata* Linné 1758, Systema Naturae, ed. 10, p. 669 (Western Europe); Dodge 1952, Bulletin American Museum Natural History **100**, Art. 1, p. 26.

*Pholas pusillus* Linné 1758, Systema Naturae, ed. 10, p. 670 (America); Dodge 1852, Bulletin American Museum Natural History **100**, Art. 1, p. 27.

*Pholas conoides* Parsons 1765, Philosophical Transactions **55**, p. 1, pl. 1 [abridged edition **12**, 1763–1769, p. 174, pl. 5, figs. 3–6].

*Pholas nanus* 'Solander' Pulteney 1799, Catalogue of the Birds, Shells, etc. of Dorsetshire [in] Hutchins History of Dorset County, p. 27 (in sides of ships at Poole and Weymouth [sic], England).

*Pholas falcata* Wood 1815, General Conchology, London, p. 84, pl. 16, figs. 5–7 [young].

*Pholas clavata* Lamarck 1818, Histoire Naturelle des Animaux Sans Vertèbres **5**, p. 446 (Seas of Western Europe and America).

*Pholas tenuistriata* de Blainville 1826, Dictionnaire de Sciences Naturelles **39**, p. 531 (Central America, based on Encyclopédie Méthodique 1792, Atlas **2**, pl. 170, figs. 4–8 [not pl. 169, figs. 4–8 as given by de Blainville]).

*Pholas decussata* 'Valenciennes' Bory de Saint-Vincent 1827, Tableau Encyclopédique et Méthodique Atlas **1**, p. 145, pl. 170, figs. 1–3.

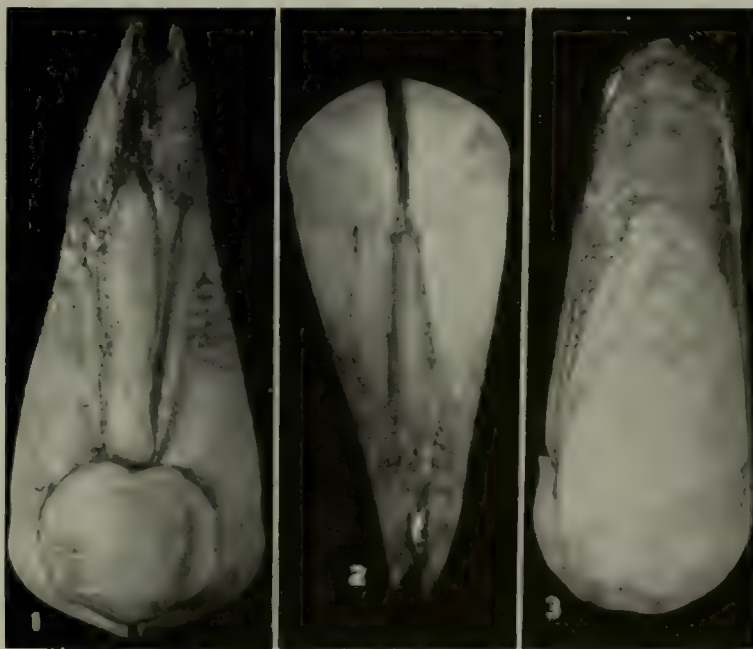


Plate 61. *Martesia striata* Linné. Fig. 1. Dorsal view of an adult specimen showing the nearly circular, inflated mesoplax and the long, narrow metaplex. Fig. 2. Ventral view showing the callum and the hypoplax. Fig. 3. Side view showing the thin, almost entirely chitinous posterior portion of the valve which is characteristic of rapidly growing specimens. All specimens are from Trinidad, British West Indies taken from a test board submerged July 16, 1948 and removed August 16, 1949 (all about  $1\frac{1}{2}x$ ).

*Pholas atomus* 'Valenciennes' Bory de Saint-Vincent 1827, Tableau Encyclopédique et Méthodique, Atlas 1, p. 145, pl. 170, figs. 4-8.

*Pholas ovum* Wood 1828, Supplement to the Index Testaceologicus, p. 2, pl. 1, fig. 4 (West Indies).

*Pholas hornbeckii* d'Orbigny 1842 [in] Sagra, Histoire Naturelle de l'Île de Cuba, Atlas, pl. 25, figs. 23-25; d'Orbigny 1853, *ibid.*, text, 2, p. 217 (St. Thomas, Hornbeck collector).

*Penitella xilophaga* Valenciennes 1846, Voyage Autour du Monde sur la Frégate La Vénus, Atlas de Zoologie, Mollusques, pl. 24, fig. 2; non *Pholas xilophaga* Deshayes 1835.

*Pholas teredinaeformis* Sowerby 1849, Thesaurus Conchyliorum 2, pt. 10, p. 490, pl. 108, figs. 97-98 (in cake of floating wax off Cuba).

*Pholas corticaria* 'Gray' Sowerby 1849, Thesaurus Conchyliorum 2, pt. 10, p. 495, pl. 108, figs. 94-96 (no locality given): [Bay of Port Royal, Kingston, Jamaica, C. B. Adams 1850, Contributions to Conchology, no. 5, pp. 75-79].

*Pholas terediniformis* Sowerby 1849 [1850] Proceedings Zoological Society London, p. 161 [error for *P. teredinaeformis* Sowerby].

*Pholas rosea* C. B. Adams 1850, Contributions to Conchology, no. 5, pp. 75-76 (Bay of Port Royal, near Kingston, Jamaica); Clench and Turner 1950, Occasional Papers On Mollusks 1, no. 15, p. 338.

*Pholas beauiana* Recluz 1853, Journal de Conchyliologie 4, p. 49, pl. 2, figs. 1-3 (Guadeloupe).

*Martesia striata* Linné, Tryon 1862, Proceedings Academy Natural Sciences Philadelphia, p. 92.

*Pholas beaniana* [sic] 'Recluz' Paetel 1890, Catalog Conchylien-Sammlung 3, p. 3 [error for *beauiana* Recluz 1853].

*Martesia curta* 'Sowerby' Dall 1909, Proceedings United States National Museum 37, p. 161; non *Pholas curta* Sowerby 1834.

*Penitella xilophaga* 'Valenciennes' Lamy 1921, Bulletin Muséum d'Histoire Naturelle, Paris 27, p. 179 [error for *P. xilophaga* Valenciennes].

*Penitella incisa*; *P. silicula*; *P. lignivora*; *P. stillata*; *P. larvata*; *P. pisum* and *P. phaseolina* all 'Valenciennes' Lamy 1921, Bulletin Muséum d'Histoire Naturelle, Paris 27, pp. 180-181. [These manuscript names of Valenciennes were introduced needlessly by Lamy as synonyms of *Martesia striata* Linné].

*Pholas cupula* Yokoyama 1924, Journal of the College of Science, Imperial University of Tokyo 45, Art. 1, p. 37, pl. 2, fig. 15 (fossil, Numa, Awa, Japan) [young]; Habe 1952, Genera of Japanese Shells, Pelecypoda, No. 3, p. 244.

*Martesia striata tokyoensis* Yokoyama 1927, Journal Faculty of Science, Imperial University of Tokyo. Section 2, 1, pt. 10, p. 428, pl. 48, figs. 2-3. (fossil, Tabata, Tokyo, Japan); Habe 1952, Genera of Japanese Shells, Pelecypoda, No. 3, p. 244.

*Martesia pulchella* Yokoyama 1932, Journal Faculty of Science, Imperial University of Tokyo, Section 2, 3, pt. 6, p. 238, pl. 2, fig. 5. (Fossil, Uryu, Ishikari Prov., Japan).

*Hiata infelix* Zetek and McLean 1936, Nautilus 49, p. 110 (Balboa, Canal Zone, Panama) [young].

*Martesia hawaiiensis* Dall, Bartsch and Rehder 1938, Bulletin B. P. Bishop Museum, no. 153, p. 205, pl. 52, figs. 1-7 (Pearl Harbor, Oahu, Hawaiian Islands).

*Martesia (Diploplax) americana* Bartsch and Rehder 1945, Smithsonian Miscellaneous Collections 104, no. 11, p. 13, pl. 2, figs. 1-2; pl. 3, figs. 3-4 (Fort Dade, Florida) [young].

*Martesia (Diploplax) funisicola* Bartsch and Rehder 1945, Smithsonian Miscellaneous Collections 104, no. 11, p. 14, pl. 3, figs. 1-2, 13-14 (Lake Worth, Florida in lead cable) [young].

*Mesopholas intusgranosa* Taki and Habe 1945, Venus 14, p. 110 (Wakayama, Honshu, Japan); Habe 1952, Genera of Japanese Shells, Pelecypoda, No. 3, p. 244.

*Mesopholas nucicola* Taki and Habe 1945, Venus 14, p. 110 (Tanabe Bay, Wakayama, Honshu, Japan).

*Martesia intercalata* 'Carpenter' Hertlein and Strong 1950, Zoologica 35, no. 19, p. 250; non *Martesia intercalata* Carpenter 1857.

*Distinctive characters.* Shell under 2 inches in length, pear-shaped, beaked anteriorly and widely gaping in the young stage, producing a callum when adult, Umbonal reflection with a funnel-shaped pit below and a sickle-shaped flange over the umbo. Mesoplax broadly oval to circular, inflated and sculptured only with irregular wrinkles. Metaplax and hypoplax long, narrow and pointed at both ends.

*Description.* Shell white, variable in size and shape, larger specimens reaching 44 mm. (about  $1\frac{3}{4}$  inches in length and 19 mm. (about  $\frac{3}{4}$  inch) in height. Generally more or less pear-shaped in outline and producing a callum in the adult stage. Young specimens beaked anteriorly and widely gaping. Beak truncated at a sharp angle to the anterior margin of the disc, giving the shell a teredo-like appearance. Posteriorly the shell is closed and broadly to narrowly rounded depending upon the age and rate of growth of the specimen. In very rapidly growing specimens the posterior slope may be greatly extended, this portion being thin and almost entirely chitinous and nearly devoid of sculpture. Valves divided into two distinct regions by a shallow but distinct umbonal-ventral sulcus. Anterior portion sculptured with close-set, denticulated, concentric ridges and usually

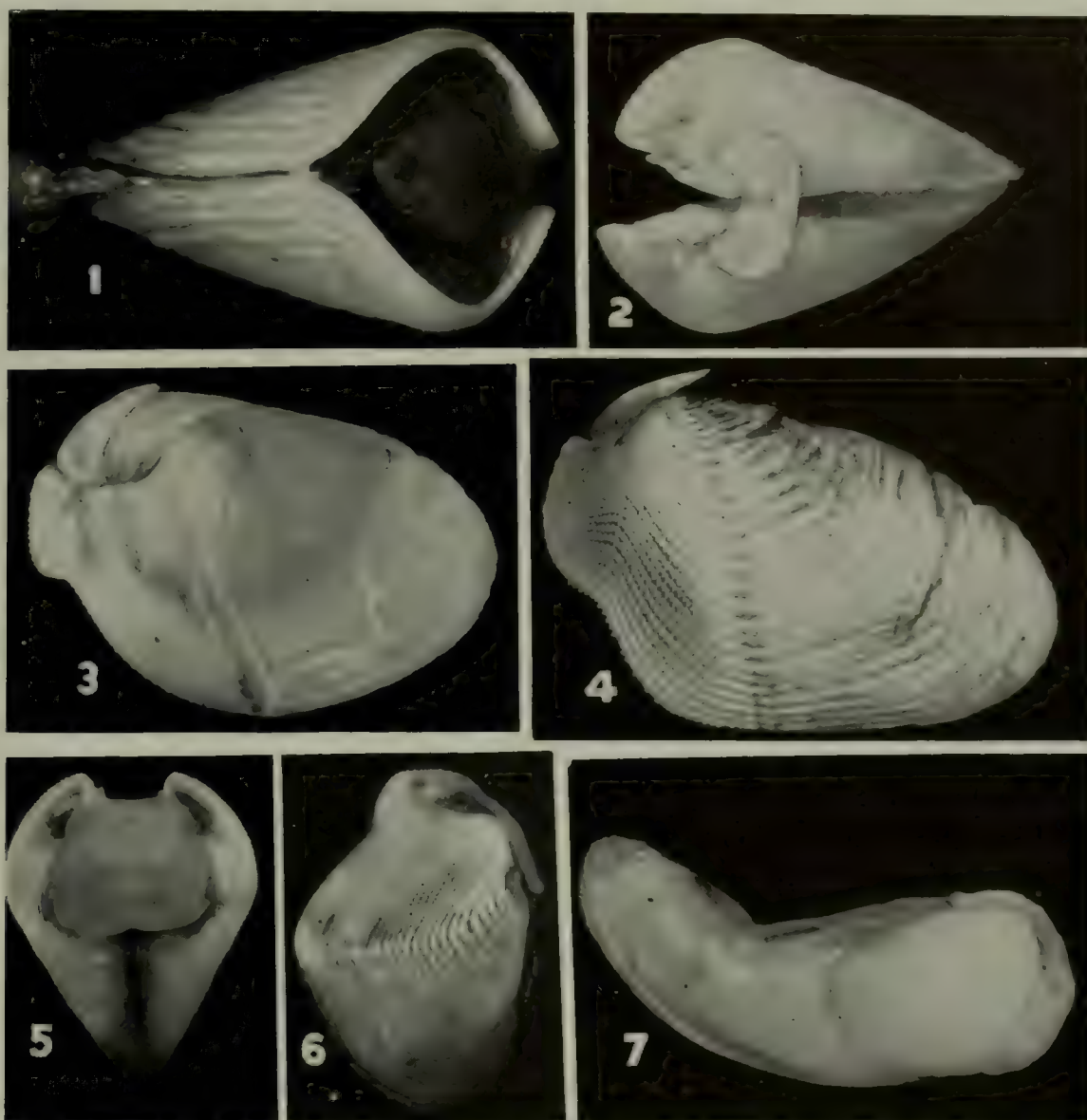


Plate 62. *Martesia striata* Linné. Fig. 1. Ventral view of a young specimen showing the large pedal gape and the foot. Punta Gorda, Florida (3x). Fig. 2. Dorsal view of young specimen with the anterior adductor muscle removed to show the flanges over the umbos and the semicircular mesoplax in place, fitting beneath the flanges. Fort Dade, Florida (3x). Fig. 3. Internal view of the valve of a young specimen to show the narrow apophysis, the umbonal-ventral ridge and the posterior adductor muscle scar. Fort Dade, Florida (3x). Fig. 4. External view of the valve of a young specimen to show the flange which is raised well above the umbo, the rather coarse denticulated ridges of the anterior slope and the low concentric ridges of the posterior portion (3x). Fig. 5. Dorsal view of the holotype of *Hiata infelix* Zetek and McLean (= *Martesia striata* Linné, young) showing the chitinous covering of the anterior adductor muscle during the young stage ( $1\frac{1}{2}x$ ). Fig. 6. Side view of the paratype of *Hiata infelix* Zetek and McLean ( $1\frac{1}{2}x$ ). Fig. 7. Side view of an adult specimen with an elongate, thin unsculptured posterior portion which is often produced when specimens grow very rapidly. This should not be confused with the siphonoplax as the metaplax and hypoplax extend the entire length (about  $2\frac{1}{2}x$ ).

weak radial ribs over the beaks. Posterior portion sculptured with smooth, concentric ridges. Umbos prominent and located nearly at the anterior end of the shell in adult specimens. In very young specimens the umbos are centrally located, but as the specimens grow the posterior slope elongates. Umbonal reflections rather small, thin, free anteriorly and broadly reflected, forming a funnel-shaped pit below. A sickle-shaped flange extends over the umbo. It is attached anteriorly, but free and raised well above the surface of the shell posteriorly. In adult specimens the pedal gape is closed by a thin but strong callum which does not extend beyond the beaks and is usually nearly devoid of sculpture. The narrow slit remaining between the two halves of the completed callum is closed by a thin sheath of periostracum leaving open only a minute anterior pore in the fully adult specimen. Protoplax lacking. Mesoplax in young specimens transverse, more or less semicircular in outline, and with a shallow U-shaped to deep V-shaped embayment anteriorly, depending upon the age of the specimen. The mesoplax in young specimens is divided into two parts by a median groove and is marked with concentric growth lines. In adult specimens the mesoplax grows dorsally and anteriorly enclosing the anterior adductor muscle. The completed mesoplax is large, inflated, nearly circular in outline, often with a slight notch posteriorly and a small point anteriorly. The dorsal surface is sculptured only with irregular wrinkles. Metaplax pointed at both ends, long, narrow and bent downward anteriorly to fit under the mesoplax. Hypoplax pointed at both ends. Siphonoplax lacking.

Interior of the shell white to light yellow in color and usually glazed. Umbonal-ventral sulcus expressed internally as a beaded ridge which forms a condyle at its ventral margin. Apophyses long and thin. Muscle scars well marked, the anterior adductor muscle being attached to the sickle-shaped flanges over the umbos. Pallial sinus broad and deep, extending anteriorly beyond the umbonal-ventral ridge. Periostracum thin, light straw-yellow in color and persistent.

Siphons white to light ivory in color, minutely papillose and capable of extension only about the length of the shell. Incurrent siphon about three times the diameter of the excurrent siphon, the aperture fringed with papillae which extend internally as ridges. Excurrent siphon lacking papillae. Foot and mantle white to light ivory in color. Foot in young specimens large, nearly circular in outline and truncate. It is atrophied in the adult. The description of the soft parts is based upon preserved material.

length*	height	ratio h:l	
44.0 mm.	19.0 mm.	2.3	Trinidad, B.W.I.
40.0	13.0	3.1	Sneads Island, Manatee River, Florida
30.0	21.5	1.4	Sanibel Island, Florida
25.0	9.0	2.7	San Juan, Puerto Rico
17.0	10.0	1.7	" " " "
5.5	2.5	2.2	" " " "
3.5	2.5	1.4	Ribault Bay, Mayport, Florida

\* All specimens measured had a complete callum

*Types.* According to Hanley (1855, p. 25) and Dodge (1952, p. 26) Linné did not have a specimen of *Pholas striata* in his collection. His only reference was to Gualtieri 1742, Index Testarum Conchyliorum, pl. 105, fig. F. We here select the figure of Gualtieri to represent the type. The locality given by Linné was Europe. We here restrict

the type locality to Kingston, Jamaica, from which locality we have a good series. Hanley and Dodge also state that Linné did not have a specimen of *Pholas pusillus* but based his description upon the figure of P. Brown 1756, The Civil and Natural History of Jamaica, p. 417, pl. 40, fig. 11. The type locality is Jamaica. The types of *Pholas clavata* Lamarek and *Penitella xilophaga* Valenciennes are in the Paris Museum according to Lamy. The types of *Pholas teredinaeformis* and *Pholas hornbeckii* d'Orbigny are in the British Museum. Paratypes of *Pholas rosea* C. B. Adams are in the Museum of Comparative Zoölogy, no. 155634. The holotype of *P. corticaria* 'Gray' Sowerby is in the British Museum. The type locality of these last two named forms is Bay of Port Royal, Kingston, Jamaica (see C. B. Adams 1850, Contributions to Conchology, no. 5, pp. 75-76, and Clench and Turner 1950, Occasional Papers On Mollusks 1, no. 15, p. 338). The holotype of *Hiata infelix* Zetek and McLean is in the Museum of Comparative Zoölogy, no. 100088. The holotype of *Martesia hawaiiensis* Dall, Bartsch and Rehder is in the United States National Museum, no. 484213, as is the holotype of *Martesia (Diploplax) americana* Bartsch and Rehder, no. 573550 and *Martesia (Diploplax) funisicola* Bartsch and Rehder, no. 573551. Paratypes of *Mesopholas nucicola* Taki and Habe are in the Museum of Comparative Zoölogy, no. 194818, from Tanabe Bay, Wakayama, Honshu, Japan. Idiotypes of *Mesopholas intusgranosa* Taki and Habe from Shirahama, Wakayama, Honshu, Japan are also in the Museum of Comparative Zoölogy, no. 194824.

*Remarks.* *Martesia striata* Linné is a very variable but distinctive species. Complete adult specimens can be distinguished readily from all other species in this genus by the

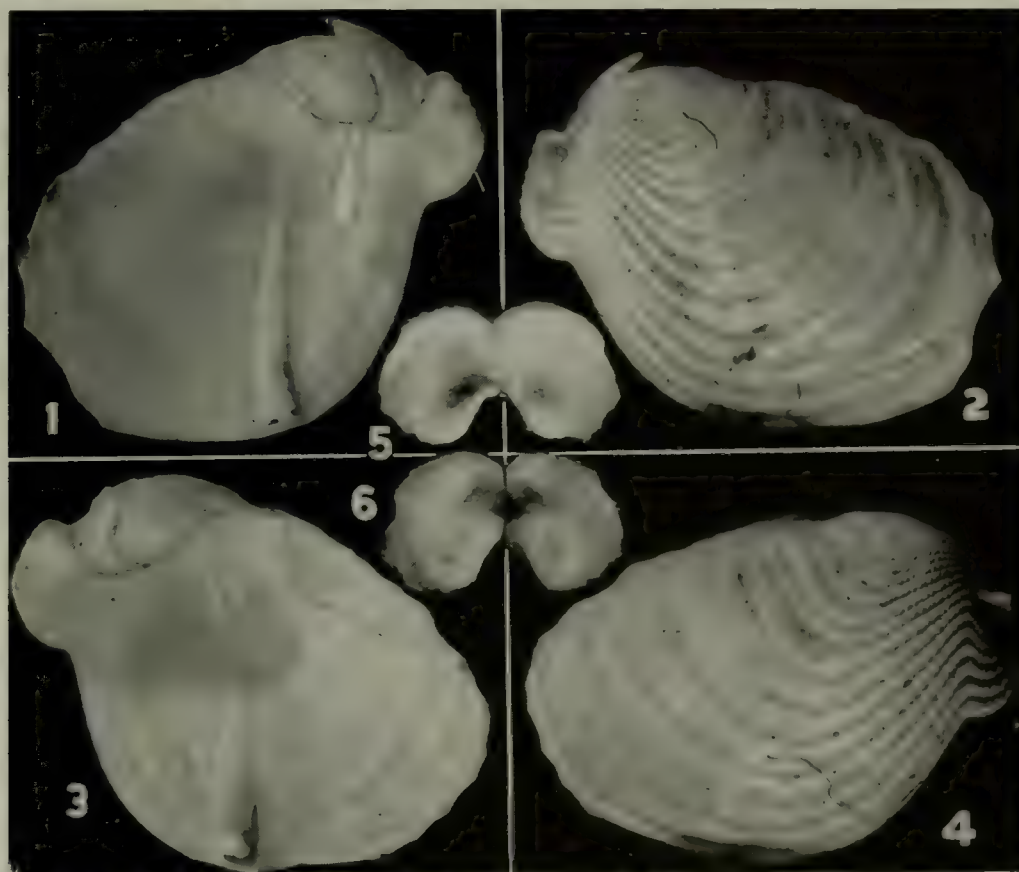


Plate 63. *Martesia striata* Linné. Figs. 1-6. Holotype of *Martesia (Diploplax) americana* Bartsch and Rehder (= *Martesia striata* Linné, young). Fig. 1. Internal view of the left valve showing the flange over the umbo, the apophysis, umbonal-ventral ridge and the posterior adductor muscle scar. Fig. 2. External view of the same valve showing the funnel-shaped pit below the umbonal reflection. Fig. 3. Internal view of the right valve; the flange over the umbo and the apophysis are both lost. Fig. 4. External view of the right valve. Fig. 5. Ventral view of the mesoplax. Fig. 6. Dorsal view of the mesoplax (all about 5x).

large, inflated, often irregularly shaped but generally nearly circular mesoplax which is sculptured only by irregular wrinkles. In specimens boring into hard wood or in overcrowded conditions the mesoplax may be malformed, often having a rough irregular surface and scalloped edges. The extensive synonymy given above reflects the great variability. We have seen type material of many of the synonyms, while others were sufficiently well described and figured as to leave no doubt as to their position. The specimens named and described as *Martesia curta* Sowerby by Dall (1909, *op. cit.*) and *Martesia intercalata* Carpenter by Hertlein and Strong (1950, *op. cit.*) have been examined and in both cases they proved to be *M. striata* Linné.

This species is most closely related to *M. fragilis* Verrill and Bush. The latter species, however, is generally smaller and more delicate, and has a depressed, broadly oval mes-

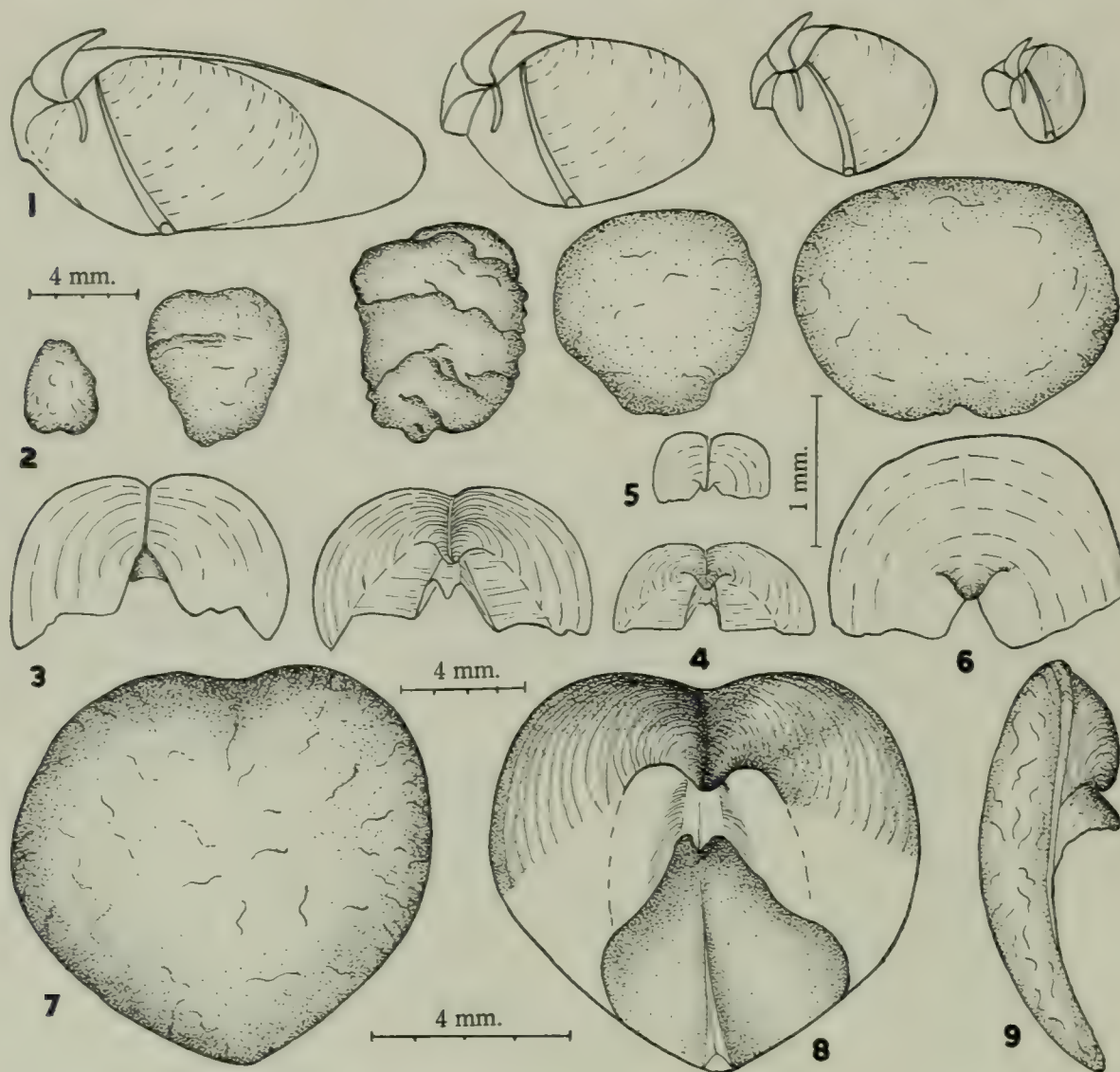


Plate 64. *Martesia striata* Linné. Fig. 1. Outline sketches of a series of specimens from young (on right) to nearly adult (on left) to show the change in shape with age. Magnification is not constant, the young specimen was only 2 mm. in length while the one on the left was  $2\frac{3}{4}$  cm. All specimens were taken from a single test board from San Juan, Puerto Rico. Fig. 2. A series of dorsal plates to show the range in shape, size and condition. The central figure is of the mesoplax from a specimen which had met obstructions in its burrow and so was deformed. Specimens from Daytona Beach, Florida and Guantánamo, Cuba. Fig. 3. Dorsal and ventral view of a mesoplax from a young specimen from St. Petersburg, Florida. Fig. 4. Ventral view of the mesoplax from a paratype specimen of *Hiata infelix* Zetek and McLean (= *Martesia striata* Linné). Fig. 5. Mesoplax from a very young specimen from San Juan, Puerto Rico to show the pronounced central groove. Fig. 6. Mesoplax from a young specimen from Guantánamo, Cuba, with a very weak central groove. Fig. 7. Dorsal view of a typical, fully-developed mesoplax to show the irregular sculpture and the cushion-like appearance. Fig. 8. Ventral view of the same specimen. Fig. 9. Side view. Figs. 7-9. From San Juan, Puerto Rico.

oplax which is always notched posteriorly and is clearly sculptured with concentric rings. The valves of *M. striata* and *M. fragilis* are generally difficult to distinguish. Those of *M. fragilis*, however, are usually shorter, more broadly rounded posterior to the umbos and more uniformly sculptured. The valves of both species are distinguished from others in the genus by the sickle-shaped flange over the umbo. The young of the two species are impossible to distinguish unless the mesoplax is present. The dorsal portion of the mesoplax in *M. striata* does not develop fully until the callum is being produced, whereas the mesoplax of *M. fragilis* develops much earlier and may be complete in a half grown specimen. The very young of the two species are completely indistinguishable, at least in preserved material.

It is surprising that so little is known concerning the biology of this species considering its economic importance in certain localities. At San Juan, Puerto Rico, Cavite, Luzon, Philippine Islands, and Pearl Harbor, Honolulu, Hawaiian Islands, this species probably equals in its destructiveness the damage caused by the Teredinidae. From one test board measuring 12"x6"x1" submerged at San Juan, Puerto Rico for eight months, we obtained 208 specimens, many of which measured over 20 mm. in length. Test board records at Guantánamo, Cuba and San Juan, Puerto Rico, indicate that this species probably breeds throughout the year. This is perhaps one explanation for its wide distribution in the tropics. It reaches maturity in one month and specimens four months old may exceed 35 mm. in length. A test board submerged at Bahia, Brasil on May 3, 1945 and removed on June 2, 1945 contained several specimens of *M. striata* with the callum completely developed, the largest specimen measuring 16 mm. in length.

This species was introduced into Sydney Harbour, Australia about ten years ago and is now becoming very destructive. Life history studies carried on by D. D. Moore<sup>1</sup> indicate that at this locality it breeds only during the warmest months of the year, that the eggs are fertilized in the water and the larvae are free-swimming for about one month. He states that "during the winter nearly all the animals of this species change sex to maleness, the warmer temperature causing a proportion of these to change to female." This statement, however, needs verification.

*Martesia striata* Linné, like other callum-building pholads, upon reaching maturity stops boring and closes off the anterior end of the shell with a calcareous deposit. The time when this takes place appears to vary greatly with the conditions of substrata and crowding of the specimens. We have seen minute specimens less than a month old with the callum fully developed and other large specimens over three months old which were still active. Working specimens when removed from their burrows are completely helpless and soon die. However, if the burrow is broken away exposing the posterior portion of the shell while leaving the anterior portion in the burrow, so that the animal can bring the shell into action, it will rapidly re-bury itself. A specimen observed burrowed about 22 mm. in 72 hours. This specimen was boring in palmetto piling. Undoubtedly one working in a harder substance would progress much more slowly.

*Martesia striata* Linné has been recorded by Pulteney and others from the British Isles, but these records, like those from Massachusetts, appear to be fortuitous. Undoubtedly they are based upon specimens taken from wooden ships that had been in the West Indies or from driftwood that had been carried by the Gulf Stream.

<sup>1</sup> D. D. Moore, Jan. 1947, Port of Sydney Journal 1, no. 3, pp. 74-75.

*Range.* WESTERN ATLANTIC: From Kure Beach, North Carolina south to Florida, the Gulf of Mexico, the West Indies and south to Rio de Janeiro, Brasil.

EASTERN PACIFIC: From Sonora, Mexico south to the Gulf of Guayaquil, Peru.

INDO-PACIFIC: Hawaiian Islands west to Japan and south through the East Indies to Brisbane, Australia.

*Specimens examined.* WESTERN ATLANTIC: NORTH CAROLINA: Kure Beach (MCZ). SOUTH CAROLINA: Sullivans Island, Charleston (Charleston Museum). FLORIDA: Mayport; Daytona Beach; Fort Pierce (all MCZ); West Palm Beach (USNM); Miami (A. Merrill); Bahia Honda Key (ANSP); Stock Island, near Key West (USNM); Estero Island, Fort Myers Beach; Sanibel Island (both MCZ); Boca Grande (ANSP); Punta Gorda (MCZ; USNM; ANSP); Manatee River, near Bradenton (A. Koto); Anna Maria (USNM); St. Petersburg (MCZ; ANSP); Gulfport (MCZ); Cedar Keys (MCZ; USNM); Port St. Joe (A. Merrill); Panama City (MCZ); Pensacola (MCZ; USNM). TEXAS: Port Isabel (MCZ). CUBA: Mariel, Pinar del Río (Museo Poey); Banes, Oriente; Guantánamo, Oriente; La Milpa, Cienfuegos, Las Villas (all MCZ); Santiago de Cuba, Oriente (USNM). JAMAICA: Port Royal; Kingston (both MCZ); Port Morant; St. Andrews (both USNM). HISPANIOLA: Torbeck; Aquin; Les Cayes; St. Louis; all Dept. du Sud, Haiti (all USNM). PUERTO RICO: San Juan (MCZ; USNM). VIRGIN ISLANDS: St. Croix (USNM; ANSP); St. Thomas (MCZ; USNM; ANSP; Redpath Museum). LESSER ANTILLES: Macqueripe Bay; Claxtons Bay; Otaheite, 5 miles southwest of S. Fernando; all Trinidad (all MCZ). MEXICO: Tecolutla, Vera Cruz (T. Pulley). GUATEMALA: Puerto Barrios (MCZ). HONDURAS: Puerto Cortez (MCZ). NICARAGUA: Greytown (USNM). PANAMA: Chagres; Fort Sherman; Cristobal; Coco Solo; Fort Amador (all MCZ). VENEZUELA: Amuay Bay; Puerto Cabello (both MCZ). BRASIL: Bahia, Bahia (MCZ); Mariqui, Bahia de Sepetiba, Rio de Janeiro; Nictheroy, Rio de Janeiro (both H. Lopes); Praia Boa Viagem, Rio de Janeiro (W. J. Eyerdam); Cananeia, São Paulo (J. P. Carvalho).

EASTERN PACIFIC: MEXICO: about 43 mi. S.E. of Altata, Sinaloa (N. Lat.  $24^{\circ}22'$ ; W. Long.  $107^{\circ}37'$ ); Bahía de Topolobampo (both R. J. Menzies); Guayamas, Sonora (USNM); Empalme Beach, Sonora (S. S. Berry); Magdalena Bay, Baja California (USNM; California Acad. Science). Barra de Cahuacan, Chiapas (Hancock Foundation). NICARAGUA: Corinto (California Acad. Science). COSTA RICA: Golfito (MCZ); San Lucas Island, Gulf of Nicoya (USNM). PANAMA: Puerto Armuelles; Panama, Canal Zone; Balboa, Canal Zone (all MCZ); Bahía Honda (N. Lat.  $70^{\circ}45'$ ; W. Long.  $81^{\circ}31'$ ) (Hancock Foundation). COLOMBIA: Isla del Gallo, Rada de Tumaco (A. A. Olsson). ECUADOR: Sua (A. A. Olsson). PERU: Tumbes (USNM).

INDO-PACIFIC: HAWAIIAN ISLANDS: Pearl Harbor, Oahu (MCZ; USNM). JAPAN: Yawatahama, Ehime, Shikoku (T. Habe); Sasebo, Kyushu (MCZ); Shirahama and Tanabe Bay, Wakayama, Honshu (both T. Habe). MARIANNAS ISLANDS: Guam (MCZ). PHILIPPINE ISLANDS: Subic Bay (MCZ; USNM); Mariveles, Bataan (USNM); Cavite, Manila Bay (MCZ; USNM); off Corregidor Light, Manila Bay; Ragay River, Ragay Gulf, all Luzon; off Marikuitdaquit Island, Leyte; Dapitan, Mindanao; Malapaya Bay, Palawan (all USNM). EAST INDIES: South of Dodeps Island, Gulf of Tomini, Celebes

(USNM): Island of Raha, south Celebes: Soengailiat, Banka Island: Rotterdam and Dapoer, Batavia Bay, Java: Wahai, Ceram: Molucca Islands (all Zool. Mus. Amsterdam). CHINA: off Pratas Island, China Sea (USNM). STRAITS SETTLEMENTS: Johore Straits (R. D. Purchon). AUSTRALIA: Brisbane (C. J. Trist).

***Martesia (Martesia) fragilis* Verrill and Bush**  
Plates 65-66

*Martesia (Martesiella) fragilis* Verrill and Bush 1890, Proceedings United States National Museum **20**, no. 1139, p. 777, pl. 79, fig. 10 (in floating wood about 360 miles off Cape Charles, Virginia, *Albatross*, station 2566).

*Pholadidea (Penitella) minuscula* Dall 1908, Bulletin Museum Comparative Zoölogy **43**, p. 425 (boring in corky envelope of large seed, Gulf of Panama, *Albatross*, station 3392).

*Martesia (Diploplax) exquisita* Bartsch and Rehder 1945, Smithsonian Miscellaneous Collections **104**, no. 11, p. 10, pl. 3, figs. 17-18 (Stony Cove, St. Mary's Parish, Jamaica).

*Martesia (Diploplax) bahamensis* Bartsch and Rehder 1945, Smithsonian Miscellaneous Collections **104**, no. 11, p. 11, pl. 3, figs. 15-16 (from a floating nut, South Bight, Andros Island, Bahama Islands).

*Distinctive characters.* Shell small, not reaching over  $\frac{3}{4}$  inch in length. Mesoplax broadly oval and depressed with a peripheral keel and concentric sculpture. The mesoplax assumes the adult form in immature specimens. Metaplax and hypoplax similar to *M. striata* Linné.

*Description.* Shell reaching 19 mm. (about  $\frac{3}{4}$  inch) in length and 11.5 mm. (about  $\frac{3}{8}$  inch) in height, generally pear-shaped and producing a callum in the adult stage. Young specimens beaked anteriorly and widely gaping: the beaks being truncated at nearly a right angle, give the shells a teredo-like appearance. Shells rounded and closed posteriorly. Valves divided into two distinct portions by a shallow umbonal-ventral sulcus. Anterior portion sculptured with close-set, concentric, denticulated ridges, and weak to moderately pronounced radial ribs. Posterior portion sculptured with smooth, rounded ridges. Umbos prominent and located very near the anterior end of the shell in adult specimens. In young specimens the umbos are nearly central, but as the posterior slope elongates, the umbos become more anteriorly located. Umbonal reflections simple, thin, free anterior to the umbos and broadly recurved forming a funnel-shaped pit below the reflection. In addition, there is a sickle-shaped flange extending over the umbos which is closely attached anteriorly but free posteriorly, and raised well above the surface of the shell. This flange is the attachment area for the anterior adductor muscle. In the adult the pedal gape is closed by a thin callum which does not extend dorsally between the beaks. The narrow slit remaining between the two halves of the callum is covered with a thin but strong periostracum leaving only a minute anterior pore open in the fully adult specimen. Mesoplax in very young specimens transverse, more or less semicircular in outline with a shallow U-shaped to deep V-shaped embayment anteriorly. It is divided longitudinally into two parts by a pronounced groove and is sculptured by concentric growth lines. The dorsal portion of the mesoplax is produced before the callum is complete so that immature specimens may also occur with nearly complete dorsal plates. Mesoplax in adult specimens circular to oval in outline, depressed and with a pronounced concentric sculpture. Metaplax long and narrow, pointed anteriorly and broadening pos-

teriorly to a rounded or truncate posterior margin. Hypoplax long and narrow, pointed anteriorly, rounded posteriorly and extending from the umbonal-ventral sulcus posteriorly about two thirds the distance to the posterior margin.

Interior of the shell white and glazed. Umbonal-ventral sulcus expressed internally as a pronounced ridge. Apophyses long, thin and extending from beneath the umbos anteriorly at a moderate angle. Muscle scars well marked, pallial sinus broad and deep, extending anteriorly in an irregular curve nearly to the umbonal-ventral ridge. Perios-tracum thin, light straw-yellow in color and persistent.

We have not seen the soft parts of this species.

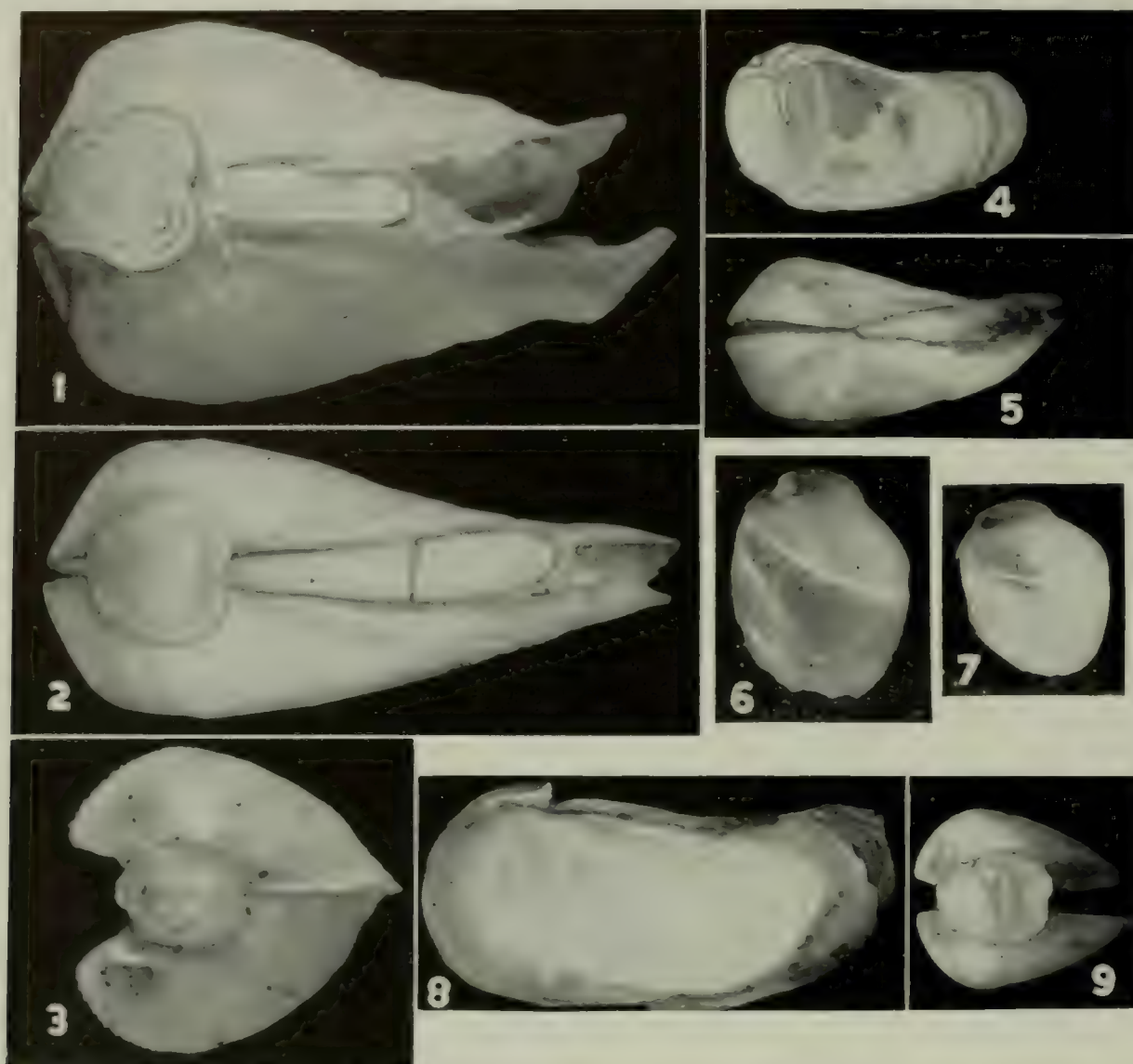


Plate 65. *Martesia fragilis* Verrill and Bush. Fig. 1. Dorsal view of the lectotype of *Martesia fragilis* showing the concentrically sculptured mesoplax (8x). Fig. 2. Dorsal view of an adult specimen from Galveston, Texas, showing the mesoplax and the metaplex (3x). Fig. 3. Paratype of *Martesia (Diploplex) bahamensis* Bartsch and Rehder (= *M. fragilis* Verrill and Bush, young) showing the mesoplax which is essentially similar to the adult form even though the callum is not produced ( $12\frac{2}{3}x$ ). Fig. 4. Internal view of an adult specimen from Galveston, Texas (3x). Fig. 5. Ventral view of an adult specimen from Galveston, Texas (3x). Fig. 6. Holotype of *Martesia (Diploplex) exquisita* Bartsch and Rehder (= *M. fragilis* Verrill and Bush, young) (about  $1\frac{1}{2}x$ ). Fig. 7. Holotype of *Martesia (Diploplex) bahamensis* Bartsch and Rehder (= *M. fragilis* Verrill and Bush, young) (about  $1\frac{1}{2}x$ ). Fig. 8. Side view of an adult specimen showing the fine sculpture on the anterior portion and the nearly smooth posterior portion. Galveston, Texas (3x). Fig. 9. Dorsal view of young specimen to show the mesoplax with its concentric sculpture and slightly concave upper surface. Sabine, Texas (3x).

length *	height	ratio h:l	
19.5 mm.	11.5 mm.	1.7	Galveston, Texas
17.5	6.5	2.6	Matagorda Island, Texas
14.0	8.2	1.7	Port Aransas, Texas
12.5	6.2	2.0	Modesto, Sinaloa, Mexico
7.5	5.0	1.5	Paratype
6.0	3.5	1.7	Lectotype

\* All specimens measured had a complete callum

**Types.** The following types are all in the United States National Museum. Lectotype, *Martesia fragilis* Verrill and Bush, no. 52543, from *Albatross*, station 2566, about 360 miles off Cape Charles, Virginia (N. Lat.  $37^{\circ}23'$ ; W. Long.  $68^{\circ}08'$ ) in a piece of floating wood. Holotype of *Martesia (Diploplax) exquisita* Bartsch and Rehder, no. 573548, from Stony Cove, St. Mary's Parish, Jamaica. Holotype of *Martesia (Diploplax) bahamensis* Bartsch and Rehder, no. 573549, taken from a floating nut [*Terminalia catappa* Linné<sup>1</sup>] collected on the eastern end of South Bight, Andros Island, Bahama Islands. Holotype of *Pholadidea (Penitella) minuscula* Dall, no. 122946, from *Albatross*, station 3392, in the Gulf of Panama (N. Lat.  $7^{\circ}5'$ ; W. Long.  $79^{\circ}40'$ ) in a nut [*Malpighia* sp.<sup>1</sup>].

**Remarks.** This species is closely related to *M. striata* Linné and has long been confused with it. Good complete specimens of *M. fragilis* may be readily differentiated, however, by the characteristic mesoplax which is depressed, has sharply keeled edges and pronounced concentric sculpture. In addition, the metaplax of *M. fragilis* is proportionately shorter and rounded to truncate posteriorly. The young of these two species are often impossible to differentiate. However, when still immature, *M. fragilis* begins the production of the dorsal portion of the mesoplax and at this stage they may be readily separated.

Similar to other species in this genus, *M. fragilis* is rather variable in size and shape, and lacking its accessory plates could not with certainty be distinguished from *M. striata* Linné. *Martesia (Diploplax) exquisita* Bartsch and Rehder, and *Martesia (Diploplax) bahamensis* Bartsch and Rehder appear to be only the young of this species.

We do not understand at present the distribution of this species. The only area where specimens have been taken in fixed structures (i.e., test boards) is the Texas coast and here their occurrence is very irregular both as to season and duration. All other records have come from floating wood or nuts. It would appear that the species is essentially

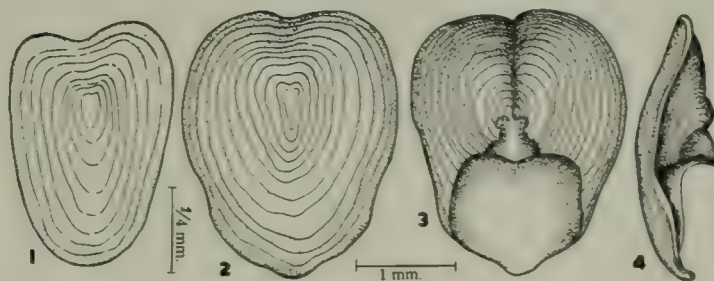


Plate 66. Mesoplax of *Martesia fragilis* Verrill and Bush. Fig. 1. Mesoplax of the holotype of *Pholadidea (Penitella) minuscula* Dall (= *M. fragilis* Verrill and Bush). Figs. 2-4. Mesoplax of the paratype of *Martesia fragilis* Verrill and Bush. Fig. 2. Dorsal view showing the concentric growth lines. Fig. 3. Ventral view. Fig. 4. Side view.

<sup>1</sup> Dr. Albert F. Hill, Botanical Museum, Harvard University, kindly made the determinations.

pelagic and probably is far more evenly distributed throughout the West Indies than the few spotted records would indicate.

*Range.* WESTERN ATLANTIC: In sporadic localities ranging from off Cape Charles, Virginia, in floating wood, south through the Gulf of Mexico and the West Indies to Rio Grande do Sul, Brasil.

EASTERN PACIFIC: From Sonora, Mexico south to the Gulf of Panama.

*Specimens examined.* WESTERN ATLANTIC: VIRGINIA: *Albatross*, station 2566 (N. Lat.  $37^{\circ}23'$ ; W. Long.  $68^{\circ}08'$ ) about 360 miles off Cape Charles (USNM). FLORIDA: Hollywood (ANSP); Oceanus (USNM). LOUISIANA: Grand Isle (USNM). TEXAS: Sabine (MCZ); Galveston (ANSP; T. E. Pulley); Matagorda Island (USNM); Port Aransas (J. Hedgpeth); Rockport (MCZ); St. Josephs Island (USNM); Corpus Christi (MCZ). MEXICO: Tampico, Tamaulipas; Progreso, Yucatan (both ANSP). BERMUDA: (MCZ). BAHAMA ISLANDS: eastern end, South Bight, Andros Island (USNM). JAMAICA: Stony Cove, St. Mary's (USNM). BRASIL: Rio Grande do Sul (MCZ; Univ. of Michigan).

EASTERN PACIFIC: MEXICO: Bacoahibampo Bay, Sonora; Mendia, Sinaloa; near Modesto, Sinaloa (all USNM). PANAMA: *Albatross*, station 3392, Gulf of Panama (N. Lat.  $7^{\circ}5'$ ; W. Long.  $79^{\circ}40'$ ) (USNM).

### Subgenus *Particoma* Bartsch and Rehder

*Particoma* Bartsch and Rehder 1945, Smithsonian Miscellaneous Collections **104**, no. 1, p. 5.

Species in the subgenus *Particoma* are characterized by having a thick, oval-shaped callus over the umbos and obliquely to sinuously truncated beaks. The mesoplax is cuneiform with a central groove from which growth lines radiate. The metaplax and hypoplax are long, narrow and divided posteriorly.

Subgenotype, *Pholas cuneiformis* Say, original designation.

### *Martesia* (*Particoma*) *cuneiformis* Say

Plates 67-68

*Pholas cuneiformis* Say 1822, Journal Academy Natural Sciences Philadelphia **2**, p. 322 (the southern coast [United States]).

*Pholas caribaea* d'Orbigny 1842 [in] Sagra, Histoire de l'Isle de Cuba, atlas pl. 25, figs. 20-22; d'Orbigny 1853, *ibid.*, text **2**, p. 216 (Cuba; Mexico).

*Pholas falcata* Sowerby [in] Reeve 1872, Conchologia Iconica **18**, *Pholas*, pl. 12, sp. 51 (Hudson's Bay); non Wood 1815.

*Pholas krebsi* 'C.B. Adams' Krebs 1864, The West Indian Marine Shells with some Remarks, Nykjöbing, Denmark, p. 113 [nomen nudum].

*Distinctive characters.* Shell small, under one inch in length, pear-shaped, widely gaping anteriorly in the young stage and producing a callum when adult. Beaks sinuously truncate. Mesoplax cuneiform and sculptured with pronounced growth lines radiating from a median longitudinal groove. Metaplax and hypoplax divided posteriorly.

**Description.** Shell reaching 21 mm. (about  $\frac{7}{8}$  inch) in length and 11.5 mm. (about  $\frac{1}{2}$  inch) in height. Generally more or less pear-shaped in outline and producing a callum in the adult stage. Young specimens widely gaping anteriorly with obliquely and sinuously truncated beaks. Shell rounded and closed posteriorly. Valves divided into two distinct portions by a narrow but well impressed umbonal-ventral sulcus. Anterior portion sculptured with close-set, concentric, denticulated ridges. Radial ribs slightly indicated in some specimens. Posterior portion sculptured with smooth, rounded, concentric ridges and faint growth lines. Umbos prominent and in adult specimens located very near the anterior end of the shell. In very young specimens the umbos are nearly centrally located. Umbonal reflection small and formed as a thick callus closely appressed over the umbos. A small funnel-shaped pit is formed below the reflection where it is free anterior to the umbos. The anterior adductor muscle scar shows as a rather deep oval depression in the umbonal reflection. In the adult the pedal gape is closed by a thin callum which extends dorsally between the beaks as a narrow margin. The slit remaining between the two halves of the completed callum is closed by a thin periostracum, leaving only a minute anterior pore open in the adult specimen. The mesoplax in young specimens (those under 4 mm. in length) is transverse and located in the normal position posterior to the umbos and beneath the posterior portion of the anterior adductor muscle. However, while the animal is still immature the mesoplax assumes the adult form and produces the dorsal portion which is more or less cuneiform in outline. It may range in shape from about twice as long as wide to nearly square and the median groove may be strongly marked or barely visible. Sculpture of the mesoplax consists only of pronounced growth lines radiating from the median groove. Metaplax long and narrow and, in fully adult specimens, is divided posteriorly, extending over the edges of the valves and fusing with

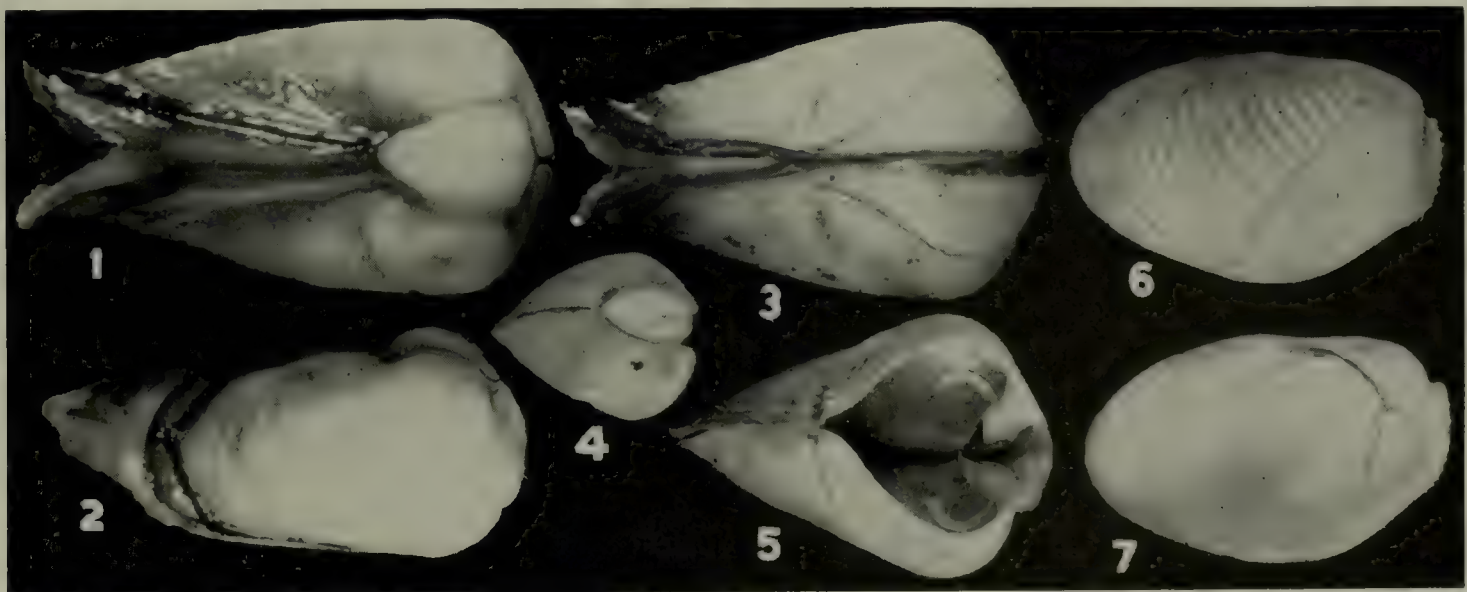


Plate 67. *Martesia cuneiformis* Say. Fig. 1. Dorsal view of an adult specimen to show the cuneiform mesoplax and the divided metaplax. Fig. 2. Side view of an adult specimen to show the chitinous "bulbs" at the posterior end of the valve and the triangular calcareous projection produced by the fusing of the divided ends of the mesoplax and the metaplax. This condition is only found in old specimens. Fig. 3. Ventral view of an adult specimen to show the callum and the divided hypoplax. Fig. 4. Dorsal view of a young specimen to show the mesoplax which is essentially similar to that of the adult. Fig. 5. Ventral view of a young specimen to show the pedal gape, the apophyses, and the chondrophore with the internal ligament still in place. Fig. 6. External view of the valve of a young specimen to show the umbonal-ventral sulcus and the rather coarse sculpture on the posterior slope. Fig. 7. Internal view of the valve of a young specimen to show the apophysis and the nearly smooth umbonal area which has only a callus but no flange.

Figs. 1-3. San Juan, Puerto Rico; Figs. 4-7. Kure Beach, North Carolina (all  $2\frac{1}{2}x$ ).

the divided hypoplax. Hypoplax narrow and extending posteriorly from the base of the umbonal-ventral ridge. In occasional specimens an incipient siphonoplax is formed. This appears as a pair of thin, triangular, calcareous projections from the posterior margin of the valves.

Interior of the shell white and glazed. Umbonal-ventral sulcus expressed internally as a strong and usually beaded ridge, which in young specimens forms a small condyle at the ventral margin. In the adult stage the ventral margin of the shell is built out beyond the condyle. Apophyses long, thin and nearly parallel with the umbonal-ventral ridge. Muscle scars well marked, the anterior adductor scar being more or less reniform and covering most of the umbonal reflection. The posterior adductor scar is a long oval. Pallial sinus broad and deep, extending anteriorly beyond the umbonal-ventral ridge. Periostracum thin, light straw-yellow and persistent.

We have not seen material sufficiently well preserved to permit a description of the soft parts of this species.

length *	height	ratio h:l	
20.5 mm.	11.5 mm.	1.7	Cumaná, Venezuela
19.0	9.0	2.1	San Juan, Puerto Rico
14.5	9.5	1.5	Wilmington, North Carolina
7.5	5.5	1.4	" " "
5.5	3.5	1.6	" " "

\* All specimens measured had a complete callum

*Types.* The holotype of *M. cuneiformis* Say is in the Academy of Natural Sciences Philadelphia, no. 50803. The type locality is here restricted to Charleston, South Carolina, a locality from which Say received considerable material. The type of *Pholas caribaea* d'Orbigny is in the British Museum according to Gray 1854; the type locality is here restricted to Guantánamo, Cuba. The location of the type of *Pholas falcata* Sowerby is unknown. It is not in the British Museum according to a letter received from G. L. Wilkins. The type locality, Hudson Bay, is unquestionably an error.

*Remarks.* This species, though variable, is very distinctive and can readily be distinguished by its cuneiform mesoplax, its small, closely appressed umbonal reflections, and its divided metaplax and hypoplax. From *Diplothyra smithii* Tryon, with which it has been confused, it differs by having a regularly sculptured, cuneiform mesoplax and by not having the callum extended on either side of the mesoplax. In addition, it is a wood-borer.

It has been impossible to separate *Martesia cuneiformis* Say from *M. caribaea* d'Orbigny. These two forms have generally been separated on the basis of the shape of the mesoplax, but it is possible to obtain specimens exhibiting the complete range of variation from a short and broad to a long and narrow mesoplax in a single test board. This variation in shape appears to be related to the rate of growth and the amount of crowding in the specimens. There is also a rather wide range of variation in the number of denticulated ridges and the size of the denticulations. As in other groups throughout the Pholadidae, these characters cannot be used safely in distinguishing species because they are readily affected by the material in which the animal is boring.

Though specimens of *M. cuneiformis* Say are recorded from New Jersey and C. W.

Johnson reports this species from Connecticut, it seems probable that its occurrence at these northern localities is fortuitous. The Clapp Laboratories have had test boards all along the coast from Connecticut to Florida for a number of years but no specimens have been taken north of Wilmington, North Carolina. It would appear, therefore, that it is unable to breed in northern waters. The above-mentioned records were probably based upon specimens carried north in driftwood by the Gulf Stream, or by wooden ships that had been cruising in the West Indies.

Little is known of the biology of this species. It is often found living in the same situation as *Martesia striata* Linné, though it is usually much less abundant. Its range in the Western Atlantic nearly coincides with that of *M. striata*, but it has only been taken at one locality in the Eastern Pacific. It is quite possible that this record may be based upon a recent introduction into the Pacific by way of the Panama Canal. It is impossible at present to explain why this species has not become widely distributed as has *M. striata* Linné.

From test-board records it would appear that this species breeds in San Juan, Puerto Rico from September to November and at Bahia, Brasil in May and June. A board submerged May 3, 1945 at Bahia, Brasil had specimens with a fully developed callum on June 2, 1945. One of these specimens had reached a length of 11.5 mm., indicating rather rapid growth.

**Range.** From Cartaret County, North Carolina south through the West Indies and Central America to Santos, Brasil. Johnson (1934) gives the range as from Connecticut south, but it would appear that this record was based on specimens that were adventitious at this locality (see Remarks).

**Records.** NEW JERSEY: Holly Beach; Atlantic City (both ANSP). NORTH CAROLINA: Core Creek Canal, Carteret Co. (Univ. of Michigan); Harbor Island (MCZ); Beaufort (USNM); Kure Beach; Wilmington; Southport (all MCZ). SOUTH CAROLINA: Myrtle Beach; Pawleys Island (both Charleston Museum); Isle of Palms; Sullivans Island (both Charleston Museum; USNM); Charleston Bay (USNM); Folly Beach (MCZ); Edisto Island (USNM). GEORGIA: Fort Screven, Chatham Co. (Charleston Museum); Sea Island, St. Simon Island (USNM). FLORIDA: Mayport (MCZ); St. Augustine (MCZ; USNM); Daytona Beach; Cape Canaveral (both MCZ); Cocoa Beach (USNM); Cape Florida (USNM); Key West (Charleston Museum); Fort Myers Beach (ANSP);

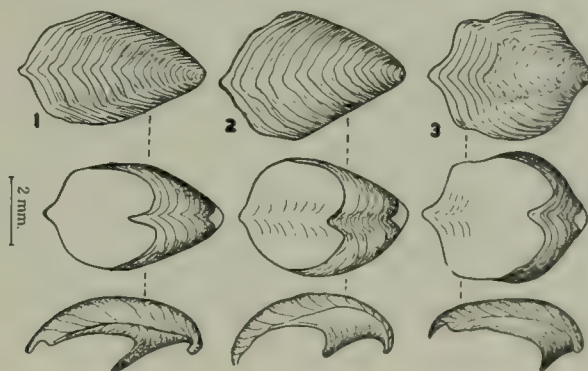


Plate 68. Mesoplax of *Martesia cuneiformis* Say. The above series shows the range in shape of the mesoplax as expressed by specimens taken from a single test board which was submerged at Mayport, Florida. Fig. 1. Dorsal, ventral and side view of a typical elongate plate of *M. cuneiformis* Say. Fig. 2. An intermediate shaped plate. Fig. 3. A broad and nearly square plate.

Sanibel Island; Captiva Island (both MCZ); Sarasota Bay (USNM); Maximo Point, St. Petersburg (M. Teare); Cedar Keys (USNM; ANSP; Univ. of Michigan); Port St. Joe (A. Merrill); Panama City; Pensacola (both MCZ). ALABAMA: Fort Morgan; Mobile (both USNM). MISSISSIPPI: Pascagoula (USNM). LOUISIANA: Grand Lake, Cameron Co. (USNM). TEXAS: Galveston (MCZ; USNM); Harbor Island, Port Aransas (MCZ). CUBA: Cabañas Bay, Pinar del Río (Museo Poey); Banes, Oriente; Guantánamo Bay, Oriente (both MCZ). JAMAICA: Kingston (MCZ). HISPANIOLA: Puerto Plata, Santo Domingo (MCZ); Bezanton, Dépt. de L'Ouest, Haiti; Aquin, Dépt. du Sud, Haiti (both USNM). PUERTO RICO: San Juan; Mayagüez (both MCZ). VIRGIN ISLANDS: St. Thomas (MCZ; ANSP). PANAMA: Fort Sherman; Cristobal; Coco Solo, all Canal Zone (all MCZ). VENEZUELA: Amuay Bay; Puerto Cabello; Cumaná (all MCZ). BRASIL: Bahia (MCZ); Santos (USNM).

EASTERN PACIFIC: PANAMA: Balboa, Canal Zone (MCZ).

### Genus *Diplothyra* Tryon

*Diplothyra* Tryon 1862, Proceedings Academy Natural Sciences Philadelphia **14**, p. 449; Lamy 1926, Journal de Conchyliologie **69**, p. 194; Bartsch and Rehder 1945, Smithsonian Miscellaneous Collections **104**, no. 11, p. 8.

Shells small, reaching about 15 mm. in length, pear-shaped in outline, divided into two distinct regions by an umbonal-ventral sulcus and producing a callum in the adult stage. Shells beaked anteriorly and widely gaping in the young stage, the beaks being obliquely truncated. Posteriorly the valves are broadly rounded and closed. Umbonal reflections thin, wide and closely appressed for their entire length. Callum produced dorsally between the beaks and extending posteriorly on either side of the mesoplax. Proto-plax lacking. Mesoplax subquadrate to subtriangulate and extending anteriorly in adult specimens to cover completely the anterior adductor muscle. Metaplax and hypoplax pointed anteriorly and forked posteriorly. The forked portions of these plates extend over the posterior margins of the valves and fuse with one another. Ventral condyles prominent in young specimens. Apophyses long and thin. Chondrophore and internal ligament well developed.

Though *Diplothyra* has been placed by Lamy (1926) and Bartsch and Rehder (1945) as a subgenus of *Martesia* the differences expressed in the mesoplax, the umbonal reflection, the extension of the callum on either side of the mesoplax, the ventral condyles and the chondrophore seem sufficient to warrant considering this a separate genus. In addition, species in this genus bore into rock and shells while species of *Martesia* are wood-borers. There are only two known species in this genus, one in the Western Atlantic, the other in the Eastern Pacific.

Genotype, *Diplothyra smithii* Tryon, monotypic.

### *Diplothyra smithii* Tryon

Plates 2; 69-71

*Diplothyra smithii* Tryon 1862, Proc. Academy Natural Sciences Philadelphia **14**, p. 450, text figure (Totenville, Staten Island, New York); Tryon 1863, Proc. Academy Natural Sciences Philadelphia **15**, p. 145; Johnson, C. W. 1905, Nautilus **18**, p. 102.

*Martesia (Diplothyra) smithii* Tryon, Bartsch and Rehder 1945, Smithsonian Miscellaneous Collections **104**, no. 11, p. 9.

*Distinctive characters.* Shell small, reaching about one half inch in length. Anterior portion triangular in outline. Callum imbedding the beaks and extending posteriorly on either side of the mesoplax. Mesoplax of adult specimens composed of a posterior portion which is concentrically sculptured and an anterior portion which is sculptured only by irregular wrinkles. Mesoplax and hypoplax forked posteriorly. Usually found in oysters and coquina rock.

*Description.* Shell small, reaching 15.5 mm. (about  $\frac{1}{2}$  inch) in length and 9.5 mm. (about  $\frac{1}{3}$  inch) in height, pear-shaped in outline, white to light brown in color, solid in structure and producing a callum in the adult stage. Immature specimens beaked and widely gaping anteriorly; rounded and closed posteriorly. Shell divided into two well defined areas by an umbonal-ventral sulcus. Anterior portion triangular in outline, sculptured by exceedingly fine, close-set, undulating, concentric ridges and numerous indistinct radial ribs. Posterior portion sculptured only by rather strong growth lines. Umbos prominent and located near the anterior fourth of the shell in normal specimens. Umbonal reflections thin, rather wide and very closely appressed for their entire length. A pronounced ridge extends longitudinally over the umbos. In the adult the pedal gape is closed by a strong callum with only a very narrow slit remaining between the two halves. The slit is covered by a heavy periostracum, leaving only a minute anterior pore open in fully adult specimens. The callum extends dorsally between the beaks, over the umbonal reflection and posteriorly on either side of the mesoplax for nearly half its length. Proto-plax lacking. Mesoplax in young specimens more or less triangular in outline and marked with concentric growth lines. The dorsal portion of the mesoplax gradually extends forward as the shell matures and, at the time the callum is produced, an unsculptured portion is added to the mesoplax which extends anteriorly between the dorsal extensions of the callum. Metaplax pointed and bent downward anteriorly, fitting against and under the mesoplax. It is divided posteriorly and the two halves extend over the posterior margins of the valves where they fuse with the two arms of the divided hypoplax. Hypoplax small and extending anteriorly to the umbonal-ventral sulcus. Siphonoplax lacking.

Interior of shell white and usually glazed. Umbonal-ventral sulcus evident internally as a low beaded ridge. Muscle scars large and well marked. Pallial sinus broad and deep, extending anteriorly beyond the umbonal-ventral ridge. Apophyses rather long, thin,

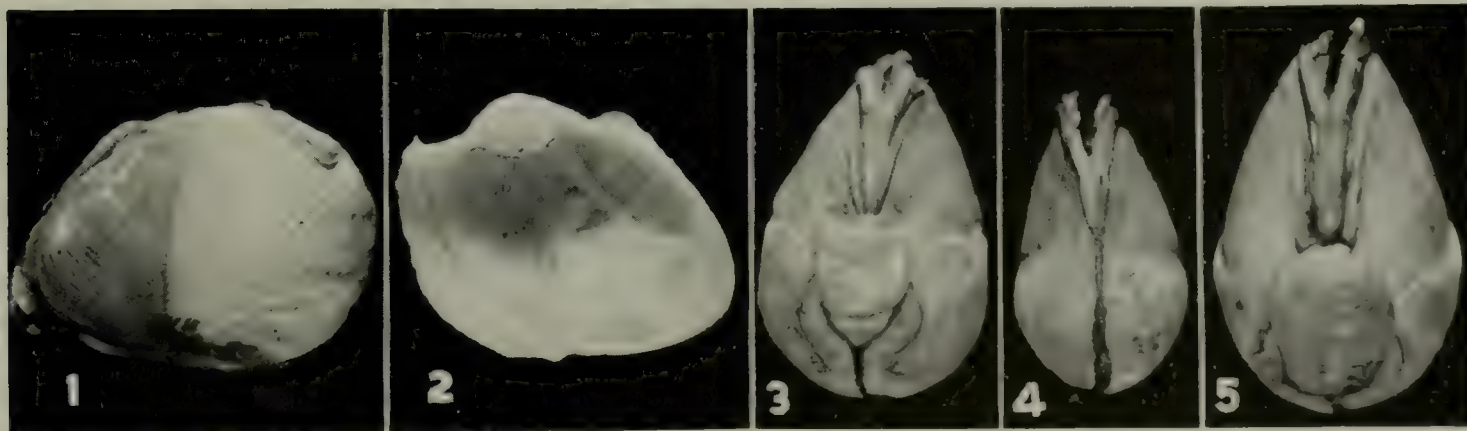


Plate 69. *Diplothyra smithii* Tryon. Fig. 1. Staten Island, New York, Lectotype. Fig. 2. Myrtle Beach, South Carolina. Figs. 3-5. Bohicket Creek, Edisto Island, South Carolina. Fig. 3. Dorsal view showing the extension of the callum on either side of the mesoplax. Fig. 4. Ventral view showing the divided hypoplax. Fig. 5. Dorsal view showing the divided metaplax (all adults, all  $3\frac{1}{2}x$ ).

narrow and fragile, extending from beneath the umbos anteriorly at a moderate angle. A pronounced chondrophore is present on the left valve.

Siphons white, smooth and short, extending only slightly beyond the end of the shell and capable of complete retraction within the shell. Foot and mantle white. Foot in young specimens large, nearly circular in outline and truncate. The foot atrophies in the adult.

length	height	ratio h:l	
14.5 mm.	8.5 mm.	1.7	St. Augustine, Florida
13.0	9.5	1.4	Daytona Beach, Florida
12.5	7.5	1.6	" " "
10.0	7.0	1.4	Paratype, Staten Island, New York
7.0	4.5	1.5	Daytona Beach, Florida

*Types.* The lectotype of *Diplothyra smithii* Tryon, here selected, is in the Academy of Natural Sciences Philadelphia, no. 51061 from Staten Island, New York. Paratypes, Museum of Comparative Zoölogy, no. 124273 and 124274 from Tottenville, Staten Island, New York.

*Remarks.* This is a very distinctive species and is not closely related to any of the small borers in the Western Atlantic. It is nearest to *D. curta* Sowerby of the Eastern Pacific, from which it differs in its divided mesoplax which in the adult stage is composed of an early concentrically-sculptured portion and a later portion which is sculptured only by irregular wrinkles. See also remarks under *D. curta* Sowerby.

*Diplothyra smithii* Tryon is the species usually found boring into oysters. It has, however, been taken from *Fasciolaria gigantea* Kiener, and may be common in coquina rock. We have a single record of *D. smithii* Tryon boring into floating wood. This is a most unusual habitat for this species and should be confirmed.

Though *D. smithii* Tryon may on occasion be very abundant in specimens of oysters,

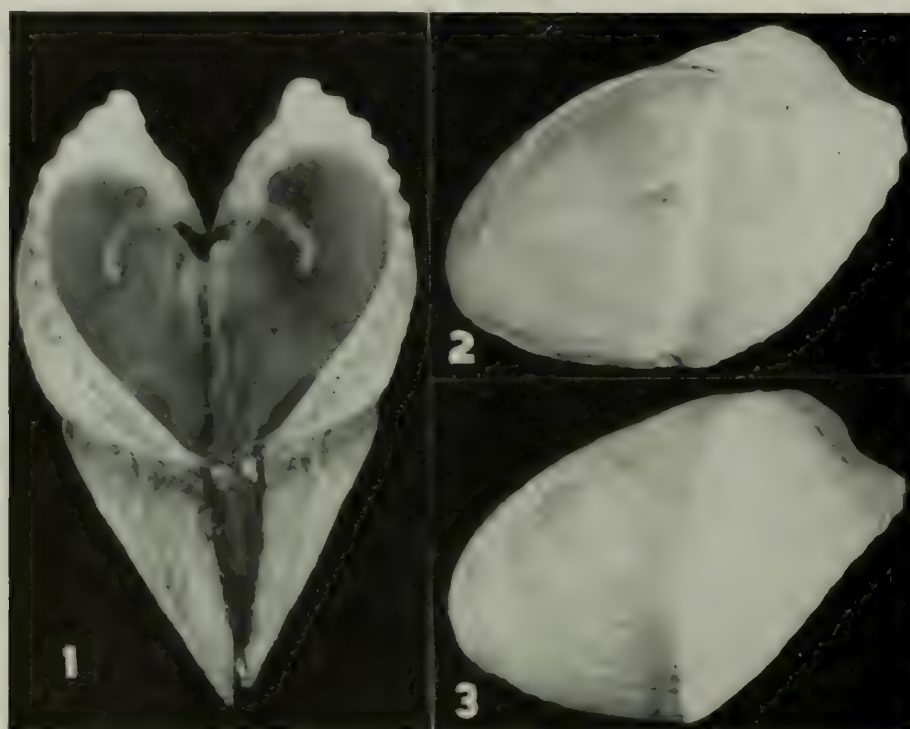


Plate 70. *Diplothyra smithii* Tryon. Figs. 1-3. Young specimens from Daytona Beach, Florida. Fig. 1. Ventral view of opposed valves showing the ventral condyles, the apophyses, and the chondrophore with the ligament still in place. Fig. 2. Internal view showing the long narrow apophyses and the muscle scars. Fig. 3. External view showing the triangularly shaped anterior portion (all  $4\frac{1}{2}x$ ).

they do not appear to injure them sufficiently to be of economic importance to the oyster fisheries.

*Range.* From Provincetown, Massachusetts south to Daytona Beach and Sanibel Island, Florida, and west to Texas.

*Specimens examined.* MASSACHUSETTS: Provincetown (MCZ). NEW YORK: Tottenville, Staten Island (MCZ; USNM; ANSP). PENNSYLVANIA: Philadelphia (USNM). MARYLAND: Crisfield (USNM); Chesapeake Bay (USNM; MCZ). VIRGINIA: Norfolk (MCZ). NORTH CAROLINA: Morehead City; Beaufort (both USNM). SOUTH CAROLINA: Bohicket Creek, Edisto Island; Sullivans Island; Myrtle Beach; Pawleys Island; Magnolia Beach (all Charleston Museum); Isle of Palms; Charleston (both USNM; Charleston Museum). FLORIDA: St. Augustine; Lake Worth (both USNM; MCZ); Daytona Beach (MCZ); Sanibel Island (A. S. Merrill); Tampa; Apalachicola (both USNM). LOUISIANA: Barataria Bay; Dutchmans Gap, St. Bernardo Parish (both USNM); Grand Isle (USNM; MCZ). TEXAS: Port Lavaca; Matagorda Bay; Keller Bay, Calhoun Co. (all USNM); Port Aransas (MCZ).

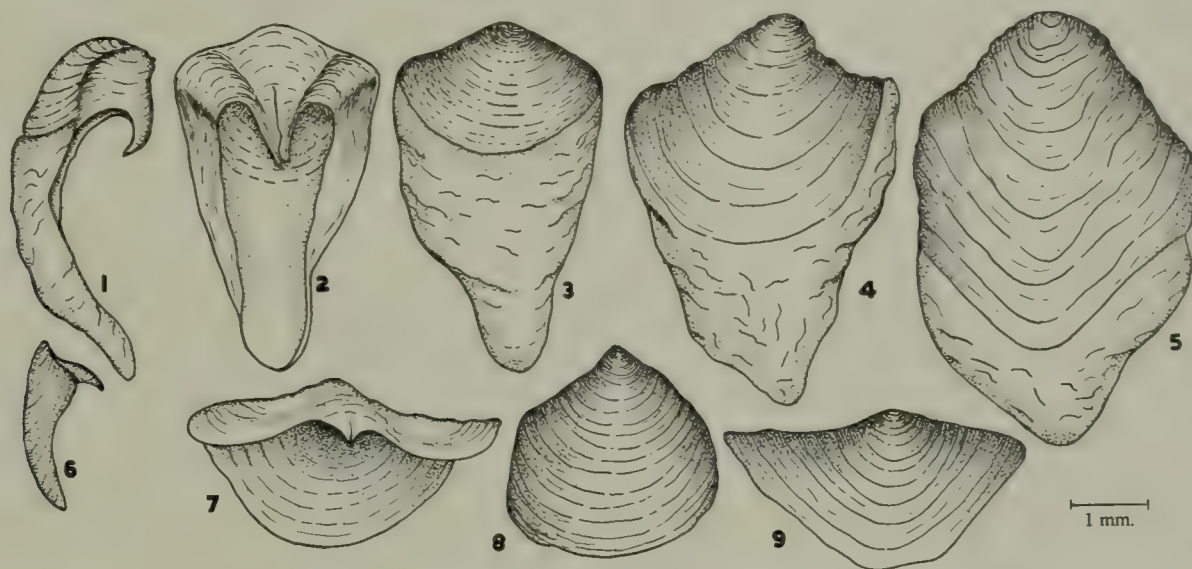


Plate 71. Mesoplax of *Diplothyra smithii* Tryon. Fig. 1. Side view of the mesoplax of an average adult specimen. Fig. 2. Ventral view of the same specimen. Fig. 3. Dorsal view of the same specimen showing the concentrically sculptured area of the young specimen and the irregular unsculptured area produced at the time the callum is formed. Figs. 4-5. Dorsal views of the mesoplax from other specimens to show the range in shape, size and proportion of the two areas. Fig. 6. Side view of the mesoplax of a typical young specimen. Fig. 7. Ventral view of an unusually wide mesoplax of a young specimen. Fig. 8. Dorsal view of the same specimen as shown in Fig. 6. Fig. 9. Dorsal view of the same specimen as shown in Fig. 7. All from specimens taken at Lake Worth, Florida.

### *Diplothyra curta* Sowerby

#### Plate 72

*Pholas curta* Sowerby 1834, Proceedings Zoological Society London, p. 71 (Isle of Lions, Province of Veragua, Columbia [Isla Leones, Golfo de Montijo, Prov. of Veraguas, Panama] in soft stone); Sowerby 1849, Thesaurus Conchyliorum 2, pt. 10, p. 494, pl. 104, figs. 33-34, pl. 108, fig. 105.

*Distinctive characters.* Shell small, reaching about one half inch in length. Callum imbedding the beaks and extending posteriorly on either side of the mesoplax. Mesoplax of adult specimens subquadrate in outline, uniform throughout and nearly smooth. Metaplastax and hypoplastax forked posteriorly. Found normally in shells and soft stone.

*Description.* Shell small, reaching about 15 mm. (about  $\frac{1}{2}$  inch) in length, pear-shaped and producing a callum in the adult stage. Immature specimens beaked and widely gaping anteriorly: rounded and closed posteriorly. Valves divided into two well defined areas by an umbonal-ventral sulcus. Anterior portion triangular in outline and sculptured by close-set imbricated ridges and radial ribs. Posterior portion sculptured only by faint growth lines. Umbonal reflections broad and closely appressed. In the adult the pedal gape is closed by a callum which extends dorsally between the beaks, usually imbedding them, and posteriorly on either side of the mesoplax for about half its length. Protoplax lacking. Mesoplax subquadrate in outline, with faint concentric sculpture and with a small point in the center of the anterior and posterior margins. Metaplax and hypoplax forked posteriorly, the forked portions extending over the posterior margins of the valves and fusing with each other in fully adult specimens. Interior of the shell similar to that of *D. smithii* Tryon.

length	height	ratio h:l	
15.5 mm.	8.5 mm.	1.8	Lectotype
11.0	8.5	1.3	Punta San Felipe, Baja California

*Types.* The types of *Pholas curta* Sowerby may be in the British Museum. The type locality as given by Sowerby is "ad littora Columbiae occidentalis. From the Isle of Lions, Province of Veragua [Isla Leones, Golfo de Montijo, Prov. Veraguas, Panama], in soft stone at low water," Hugh Cuming collector. The label on the cotype specimens in the British Museum gives Bay of Caraccas, West Colombia [Bahía de Caráquez, Ecuador],

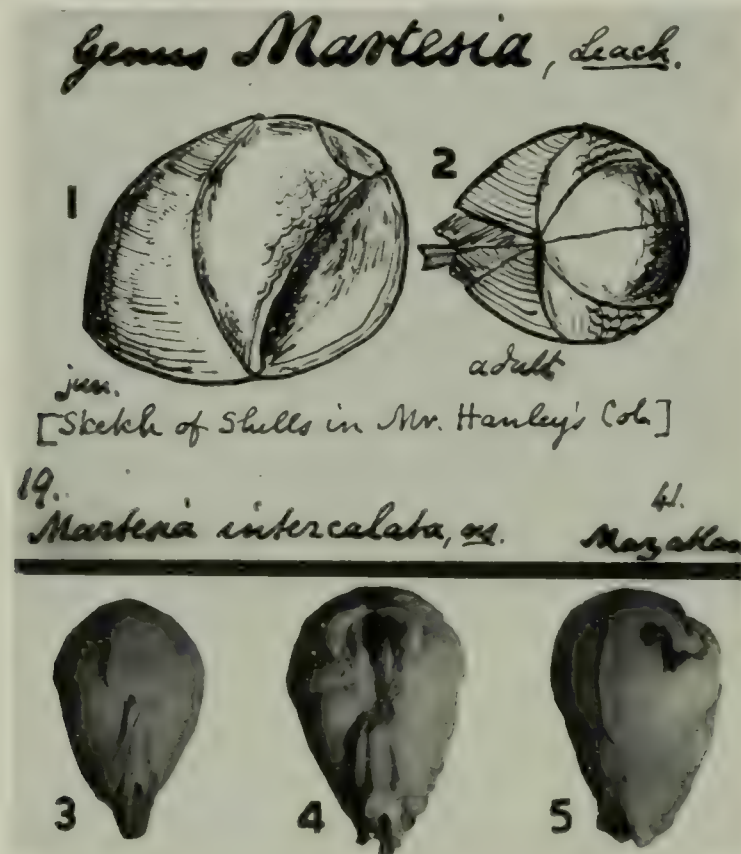


Plate 72. Figs. 1-2. Original sketches by P. P. Carpenter of the type specimens of *Martesia intercalata* Carpenter (= *Penitella conradi* Valenciennes). Figs. 3-5. *Diplothyra curta* Sowerby, Cotypes (2x). Fig. 3. Dorsal view showing the subquadrate mesoplax and the forked metaplax. Fig. 4. Dorsal view of an adult specimen lacking the mesoplax but showing the dorsal extension of the callum which extends on either side of the mesoplax. Fig. 5. Ventral view of an adult specimen showing the large callum and the forked hypoplax.

All photographs received through the kindness of Mr. G. L. Wilkins, British Museum (Natural History).

Hugh Cuming collector. We figure these specimens, photographs of which were received through the kindness of G. L. Wilkins of the British Museum.

*Remarks.* *Diplothyra curta* Sowerby is very close in its relationship to *D. smithii* Tryon and when more material is available for study these two may prove to be only subspecifically different. The nearly smooth uniform mesoplax of *curta* is the only character which distinguishes the two species.

This is an exceedingly rare species and most published references to it seem to have been based upon malformed specimens of *Martesia striata* Linné. Nothing is known of the biology of this species, though it is probably similar to that for *D. smithii*. It is found in the intertidal zone and out to depths of at least 10 fathoms.

*Range.* From the mouth of the Colorado River, Gulf of California south to Libertad, Ecuador.

*Specimens examined.* MEXICO: Colorado River, Gulf of California (USNM); Punto San Felipe, Baja California (S. S. Berry). PANAMA: Balboa, Canal Zone (USNM). ECUADOR: off Libertad (S. Lat.  $2^{\circ}07'30''$ ; W. Long.  $80^{\circ}56'30''$ ), in 10 fathoms (Hancock Foundation).

### Genus *Parapholas* Conrad

*Parapholas* Conrad 1848, Proceedings Academy Natural Sciences Philadelphia 4, p. 121.

Shell moderate to rather large in size, beaked and gaping anteriorly in the young stage and producing a callum when adult. Shells broadly rounded to acuminate posteriorly and closed. Accessory plates consisting of a mesoplax, metaplax and hypoplax. Valves divided into three distinct regions, the anterior beaked portion being separated from the disc by an umbonal-ventral sulcus. The posterior slope, which is sculptured with a series of overlapping chitinous plates, is separated from the disc by a slight groove or ridge extending from the umbos to the posterior ventral margin. Siphonoplax lacking, being replaced by a tube or "chimney" composed of fine particles which have been ejected from the siphons and then cemented together.

The genus *Parapholas* is distributed throughout the temperate and tropical portions of the Eastern Pacific and the Indo-Pacific, with one species, *Parapholas branchiata* Gould occurring in West Africa.

Genotype, *Pholas californica* Conrad, monotypic.

### Key to the American species of *Parapholas*

1. Adult shells generally under  $2\frac{1}{2}$  inches in length. Mesoplax enlarged, extending anteriorly over the beaks . . . . . 2  
 Adult generally over  $2\frac{1}{2}$  inches in length. Mesoplax not enlarged, extending about one half the distance to the beaks . . . *P. californica*
2. Mesoplax truncate posteriorly. Posterior margin of the shell acuminate. Chitinous plates on the posterior slope angled . . . . . *P. acuminata*  
 Mesoplax lobed posteriorly, extending back on either side of the metaplax. Posterior margin of the shell narrowly rounded, chitinous plates on the posterior slope rounded . . . . . *P. calva*

**Parapholas californica Conrad**

## Plates 73-77

*Pholas californica* Conrad 1837, Journal Academy Natural Sciences Philadelphia 7, p. 236, pl. 18, figs. 5-6 (San Diego and Santa Barbara, California in soft rocks).

*Pholas janellii* Deshayes 1839, Revue Zoologique par la Société Cuvérienne 2, p. 357; Deshayes 1840, Magasin de Zoologie Guérin-Méneville (2) 2, Mollusques, pls. 14-16 and text (shore of California).

*Parapholas californica* Conrad 1848, Proceedings Academy Natural Sciences Philadelphia 4, p. 121; Fitch, J. E. 1953, State of California, Dept. of Fish and Game, Fish Bulletin, no. 90, p. 96.

*Distinctive characters.* Adult shell usually over  $2\frac{1}{2}$  inches in length. Mesoplax extending about one half the distance to the beaks. Metaplax pointed posteriorly. Hypoplax pointed anteriorly, broadly rounded posteriorly. Chitinous plates on the posterior slope rounded.

*Description.* Shell reaching 149 mm. (about  $5\frac{3}{4}$  inches) in length, oval in outline, solid in structure and producing a callum in the adult stage. Immature specimens beaked and gaping widely anteriorly. Shell tapering posteriorly to a broadly rounded or truncate posterior margin. Valves divided into three well defined regions. Anterior beaked portion sculptured with very close-set, upturned, undulating, concentric ridges and weak radial ribs. Anterior portion separated from the median area or disc by a pronounced umbonal-ventral sulcus. Disc sculptured only by pronounced growth lines. Posterior slope separated from the disc by a ridge extending from the umbo to the posterior ventral margin. Posterior slope, on a shell devoid of periostracum, sculptured with strong

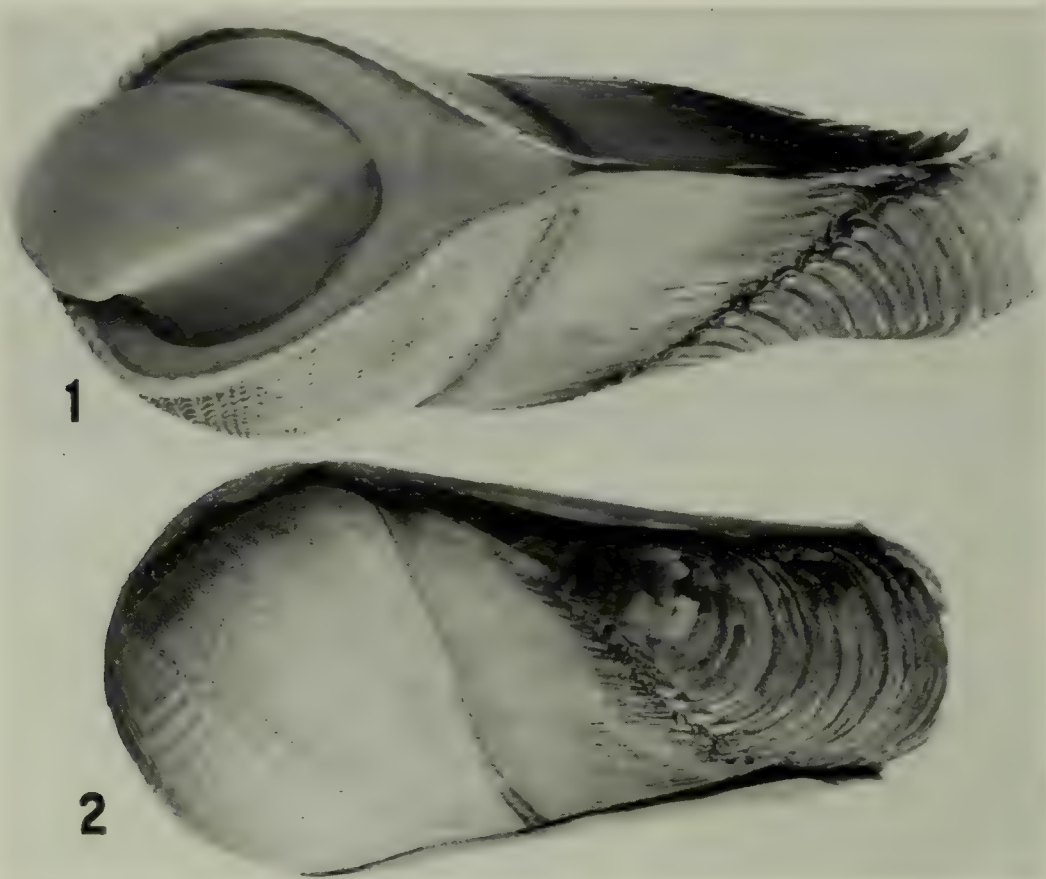


Plate 73. *Parapholas californica* Conrad. White Point, San Pedro, California (about  $\frac{5}{8}$  natural size). Fig. 1. Ventral view of young specimen showing the pedal gape, the characteristic foot and the overlapping chitinous plates on the posterior slope. Fig. 2. Lateral view of an adult showing the callum, the metaplax and the hypoplax.

Photographs received through the kindness of J. E. Fitch of the California Fisheries Laboratory, Terminal Island.

growth lines. In fresh and particularly young specimens this portion of the shell is covered by a series of rounded, overlapping, chitinous plates. Umbonal reflection simple, narrow and raised slightly above the surface of the umbo. In adult specimens the large pedal gape is closed by a heavy callum, only a very narrow slit remaining and this is covered by heavy periostracum except for the small anterior pore. Callum slightly ridged transversely, indicating the forward extension of the radial ribs. Protoplax lacking, being replaced by the dorsal extension of the callum and the anterior extension of the enlarged mesoplax of the adult. Line of contact between the callum and the mesoplax barely visible in most living specimens and often with an apparent fusion of the two in older specimens. Mesoplax in young specimens thin, small and more or less U-shaped. In the adult, the dorsal portion of the mesoplax becomes enlarged and produced anteriorly: it is broadly oval in outline and divided longitudinally by a deep sulcus. In adult specimens the dorsal margins of the valves posterior to the umbos are reflected and recurved, nearly enclosing the posterior adductor muscle. The space between the reflections is covered by a long, narrow metaplax. It is truncate and sharply bent downward anteriorly, fitting closely against the posterior margin of the mesoplax. Posteriorly the metaplax tapers to a rounded point. The narrow ventral gape is covered by a long, narrow plate, the hypoplax, which is pointed anteriorly and rounded posteriorly. Periostracum ranging in color from a dark golden-brown to nearly black. It is rather heavy on the disc, and on the posterior slope it is produced as a series of overlapping plates.



Plate 74. *Parapholus californica* Conrad. San Diego, California. Fig. 1. Ventral view showing the hypoplax in place. Fig. 2. The chimney. Fig. 3. Dorsal view showing the metaplax and mesoplax in place and the dividing line between the mesoplax and the dorsal extension of the callum (all slightly reduced).

No true siphonoplax is produced, but instead, there is a characteristic tube or "chimney" composed of the finely-worked material which is ejected by the siphons and cemented together to form a thick tube which fits over the posterior end of the shell and into which a portion of the chitinous plates of the posterior slope may extend.



Plate 75. *Parapholas californica* Conrad. Santa Cruz, California. Internal view of valve showing the apophysis, the dorsal extension of the callum, the muscle scars and the pallial sinus, and the cavity beneath the metaplex ( $1\frac{1}{4}x$ ).

Interior of shell white and glazed. Muscle scars elongate and clearly marked especially in older specimens. Umbonal-ventral sulcus expressed internally as a strong ridge which forms a condyle at the ventral margin. Pallial sinus nearly as broad as the shell is high and extending anteriorly nearly to the ventral condyle. Apophyses rather large, broad, and spooned at the ventral margin, extending from beneath the umbo anteriorly at a rather sharp angle.

Siphons not extending more than one and one half times the length of the shell and capable of complete retraction within the shell. They are white to light ivory for most of the length, smooth and devoid of periostracum. Incurrent siphon nearly three times

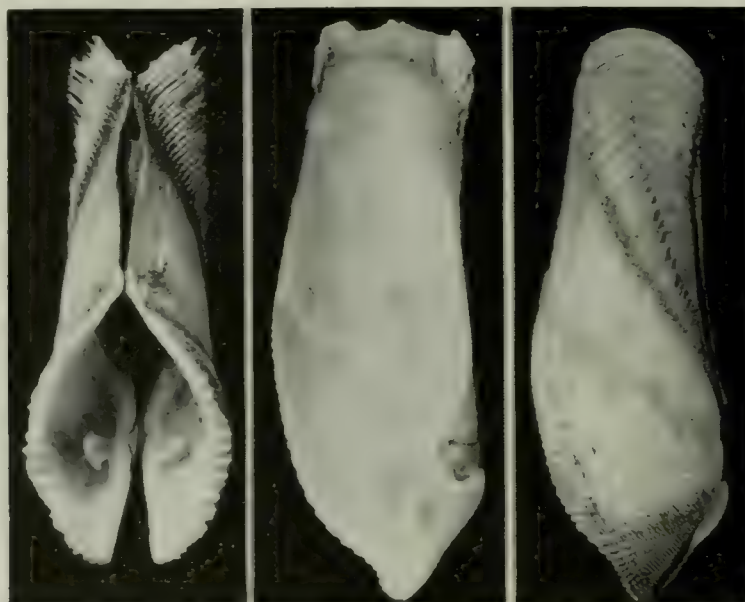


Plate 76. *Parapholas californica* Conrad. Del Monte Beach, Monterey Bay, California. Young working specimens showing the chitinous plates on the posterior slope, the apophyses, the umbonal-ventral ridge and the pedal gape.

the diameter of the excurrent siphon and surrounded at the opening by numerous branched cirri. Excurrent siphon nearly smooth. A second ring of cirri surround the combined siphons just a short distance anterior to the opening. The area between this and the openings is a dark red-gray to red-brown in color and is covered with numerous white papillae. When extended, the siphons usually appear gray in color. Foot in young specimens more or less elliptical in outline, rounded anteriorly, pointed posteriorly and truncate. Foot and mantle white to light ivory in color. The foot atrophies in the adult and the mantle is completely closed except for a minute anterior pore.

length*	height	ratio h:l	
149.0 mm.	74.5 mm.	2.0	Monterey, California
121.0	67.0	1.7	" "
115.0	49.5	2.3	San Diego, California
60.5	16.8	3.5	" " "

\* All specimens measured had a complete callum

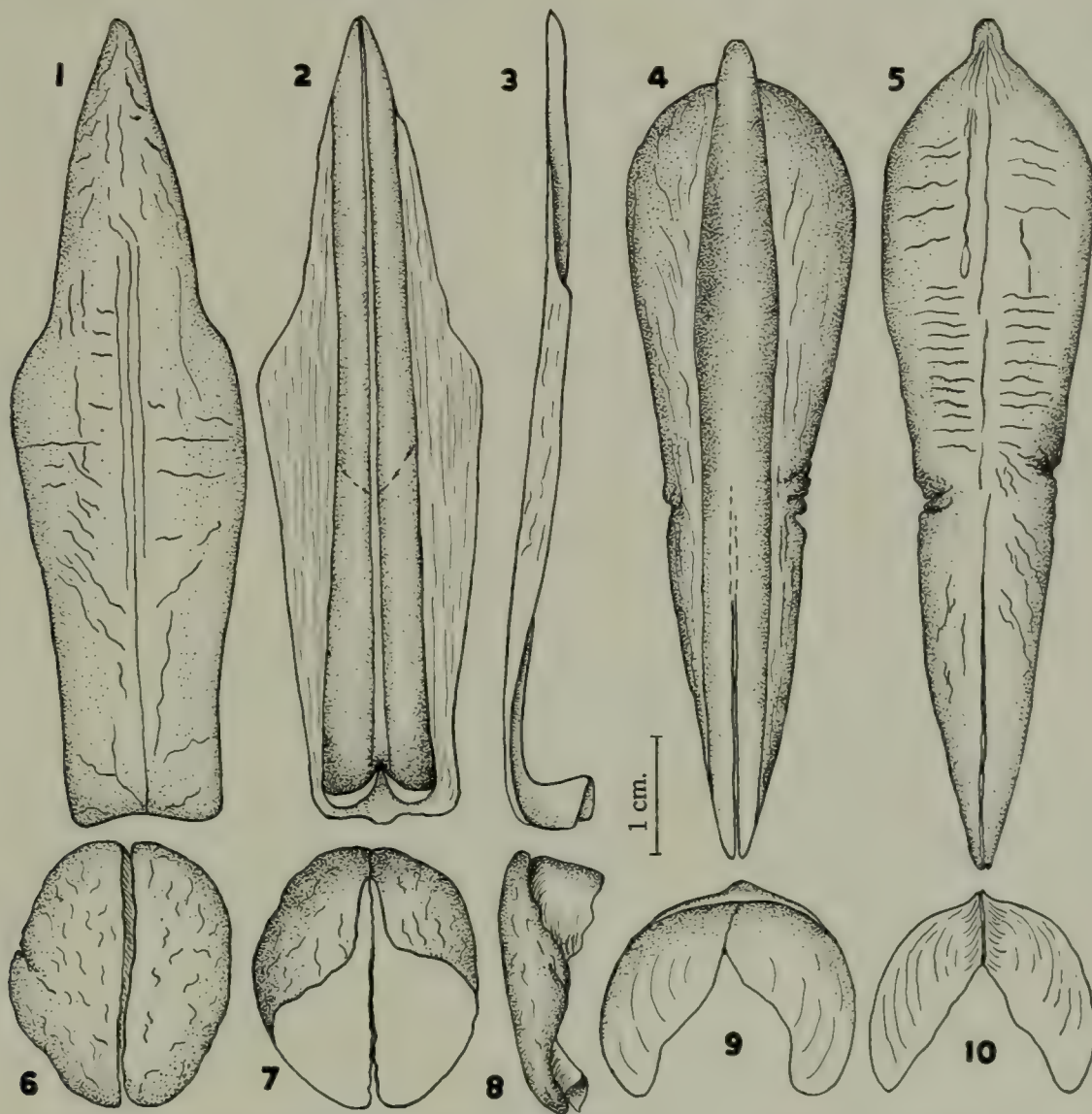


Plate 77. Accessory plates of *Parapholas californica* Conrad. Fig. 1. Dorsal view of the metaplast to show the truncated anterior end and the pointed posterior end. Fig. 2. Ventral view of the metaplast. Fig. 3. Side view of the metaplast to show the configuration of the anterior end where it bends sharply downward to fit against the posterior end of the mesoplast. Fig. 4. Internal (dorsal) view of the hypoplast to show the pointed anterior end, the rounded point of the posterior end and the cavity into which the muscular margin of the mantle fits. Fig. 5. External (ventral) view of the hypoplast. Fig. 6. Dorsal view of the mesoplast to show its nearly circular outline and central division. Fig. 7. Ventral view of the mesoplast to show the cavity into which the anterior adductor muscle fits. Fig. 8. Side view of the mesoplast. Fig. 9. Dorsal view of the mesoplast of a young specimen. Fig. 10. Ventral view of the mesoplast of a young specimen.

Figs. 1-8. From specimens collected at San Francisco, California. Figs. 9-10. From specimens collected at White Point, San Pedro, California.

*Types.* The location of the type specimens of *Pholas californica* Conrad is unknown, the type locality is San Diego, California. The type of *Pholas janellii* Deshayes is possibly in the British Museum, the type locality is the shores of California.

*Remarks.* *Parapholas californica* Conrad is a very distinctive species and is readily distinguished from all other species in this genus by its much larger size, its divided mesoplax which may be fused with the dorsal extension of the callum, and its rounded to truncate posterior margin. See also remarks under *P. acuminata* Sowerby and *P. calva* Sowerby.

*Parapholas californica* Conrad, along with *Penitella penita* Conrad and *Chaceia ovoidea* Gould, is found boring into clay, shale and soft friable stone, but is never a deep borer. Mr. John E. Fitch has written that the deepest he has ever had to dig for a *P. californica* Conrad was ten inches and that a four-inch specimen would seldom be more than eight inches down. This species is found wherever proper ecological conditions exist from the intertidal zone out to depths of 20 to 30 feet.

*Range.* Bodega Lagoon, Sonoma County, California south at least as far as Bahía San Bartolomé, Baja California. Dall's record for Coos Bay, Oregon (*Nautilus* 1897 11, p. 66) is probably in error.

*Specimens examined.* CALIFORNIA: Bodega Lagoon, Sonoma County (Hancock Foundation); Santa Cruz (MCZ); Monterey (MCZ; USNM; ANSP; J. E. Fitch); Del Monte Beach (MCZ; E. P. Chace); Santa Barbara (USNM); San Pedro (ANSP); White Point, San Pedro (E. P. Chace; USNM); Anaheim Bay (MCZ); Portuguese Bend, Orange County (Hancock Foundation); La Jolla (MCZ; Charleston Museum); San Diego (MCZ; USNM; ANSP; Hancock Foundation). MEXICO: Bahía San Bartolomé, Baja California (J. E. Fitch).

### **Parapholas acuminata Sowerby**

Plates 78-80

*Pholas acuminata* Sowerby 1834, Proceedings Zoological Society London, p. 70; Sowerby 1849, Thesaurus Conchyliorum 2, pt. 10, p. 492, pl. 105, figs. 48-50 (Panama); non *Pholas acuminata* Conrad 1845; Fischer 1858, Journal de Conchyliologie 7, pp. 169-177, pl. 6, figs. 1-11.

*Parapholas acuminata* Sowerby, Carpenter 1855, Catalogue of the Reigen Collection of Mazatlan Mollusca, p. 12; Lamy 1926, Journal de Conchyliologie 69, p. 163.

*Distinctive characters.* Shell about  $2\frac{1}{2}$  inches long. Mesoplax greatly enlarged, completely covering the beaks anteriorly; truncate posteriorly. Chitinous plates on the posterior slope angled. Metaplax and hypoplax forked posteriorly.

*Description.* Shell reaching 61 mm. (about  $2\frac{1}{2}$  inches) in length and 29 mm. (about  $1\frac{1}{4}$  inches) in height, pear-shaped, heavy, solid in structure and producing a callum in the adult stage. Immature specimens beaked anteriorly and widely gaping; tapering posteriorly to a narrowly rounded and often pointed posterior margin. Shell divided into three well defined areas. Anterior portion sculptured with extremely close-set, low, up-turned, concentric ridges and numerous radial ribs. Ribs indicated mainly by the radial arrangement of the rows of undulations. Anterior slope separated from the disc by a nar-

row umbonal-ventral sulcus. Disc sculptured by growth lines and separated from the posterior slope by a slight groove extending from the umbo to the posterior ventral margin. Posterior slope sculptured by growth lines only on a shell devoid of periostracum. On fresh specimens it is covered by a series of angled overlapping chitinous plates. Umbonal reflections in young specimens narrow, rather thick and free for the entire length. Dorsal margin of valves posterior to the umbos, only slightly reflected and recurved. Pedal gape closed in the adult stage by a rather heavy callum with a very narrow slit remaining between the two halves; the slit is covered with a heavy periostracum, leaving only a minute anterior pore in the fully adult specimen. Callum sculptured with faint growth lines and parallel ridges which are the extensions of the radial ribs. The callum does not extend dorsally between the beaks. Mesoplax in the adult greatly enlarged and extended anteriorly, completely covering the anterior adductor muscle and the beaks. It is broadly oval in outline, terminating anteriorly in a small point which fits in between the two halves of the callum. The mesoplax of the young specimen is unknown. Metaplex long and narrow; rounded and sharply bent downward anteriorly so that it abuts closely against the mesoplax; tapering and forked posteriorly. Hypoplax pointed anteriorly and forked posteriorly. Siphonoplax lacking. Chimney extending down over the surface of the shell anteriorly as far as the mesoplax. Periostracum dark brown to almost black in color, heavy on the disc and produced as overlapping angled plates on the posterior slope.

Interior of shell white to grayish-green in color and usually glazed. Umbonal-ventral sulcus evident internally as a strong ridge which, in young specimens, extends beyond the ventral margin of the valve to form a condyle. In the adult, the shell is built out beyond the end of the umbonal-ventral ridge and the condyle. Posterior adductor muscle scar elongate and well marked. Pallial sinus rather small, extending anteriorly about one half the distance to the umbonal-ventral ridge.

The soft parts of this species were unavailable for study, but according to Fischer



Plate 78. *Parapholas acuminata* Sowerby. Figs. 1-2. Panama Bay, one mile off the canal entrance in 10 fathoms. Fig. 1. Dorsal view showing the mesoplax, which is truncate posteriorly, and the divided metaplex. Fig. 2. Side view showing the angled plates on the posterior slope and the extension of the mesoplax anteriorly covering the beaks. Fig. 3. Ventral view showing the hypoplax which is pointed anteriorly and divided posteriorly (all natural size).

(1858) the siphons are short, capable of complete retraction within the shell, and the openings are surrounded with triangular cirri. The mantle is similar in color to the mantle of *Mytilus*.

length *	height	ratio h:l	
61.0 mm.	29.0 mm	2.10	Panama Bay, off the canal
52.3	22.0	2.37	Panama
44.5	20.0	2.20	Mazatlan, Mexico
34.5	16.9	2.04	Panama Bay
28.0	14.5	1.93	La Libertad, Ecuador

\* All specimens measured had a complete callum

*Types.* The type of *Pholas acuminata* Sowerby is in the British Museum according to a letter received from G. L. Wilkins. The type locality is Panama, Hugh Cuming collector.

*Remarks.* *Parapholas acuminata* Sowerby is probably most closely related to *P. calva* Sowerby and has often been synonymized with that species. It differs, however, in being much more acuminate posteriorly, having the chitinous plates on the posterior slope angled rather than rounded, and by having the mesoplax truncate rather than lobed posteriorly. It is also close in its relationship to *Parapholas californica* Conrad from which it differs by being much smaller in size, by being sharply pointed posteriorly and having a much larger mesoplax, with the metaplax and hypoplax being forked posteriorly.

*Parapholas acuminata* Sowerby is apparently a very rare species to judge from the few specimens available for study. It bores into limestone and probably other soft stone and clay. The burrow is lined with agglutinated particles from its borings so that a "chimney" is produced which extends down over the surface of the shell at least as far as the mesoplax. It is found living in depths of from two to ten or more fathoms.



Plate 79. *Parapholas acuminata* Sowerby. Panama. Fig. 1. Inner view of an adult shell showing the elongate posterior muscle scar. Fig. 2. External view of young specimen showing the high umbonal reflection. Fig. 3. Internal view of young specimen showing muscle scars, pallial sinus and apophysis. Fig. 4. Chimney (the circular hole in the side of the chimney was made by another borer) (all about  $1\frac{3}{4}x$ ).

*Range.* From San Martin Island, near San Quintin, Baja California south at least as far as Bocapán, Peru.

*Specimens examined.* MEXICO: San Martin Island, near San Quintin in 2 to 3 fathoms (USNM); Mazatlan (MCZ: S. S. Berry). PANAMA: (AMNH: MCZ: USNM): Panama Bay, one mile off canal entrance in 10 fathoms (Stanford Museum: E. P. Chace). GALAPAGOS ISLANDS: Chatham Island (USNM). ECUADOR: Manta (USNM: A. A. Olsson); off La Libertad (S. Lat.  $2^{\circ}12'15''$ ; W. Long.  $80^{\circ}53'40''$ ) in 4 fathoms (Hancock Foundation); Crucita; San Pedro, near Manglaralto; Santa Elena Peninsula: Salinas (all A. A. Olsson). PERU: Bocapán (A. A. Olsson).

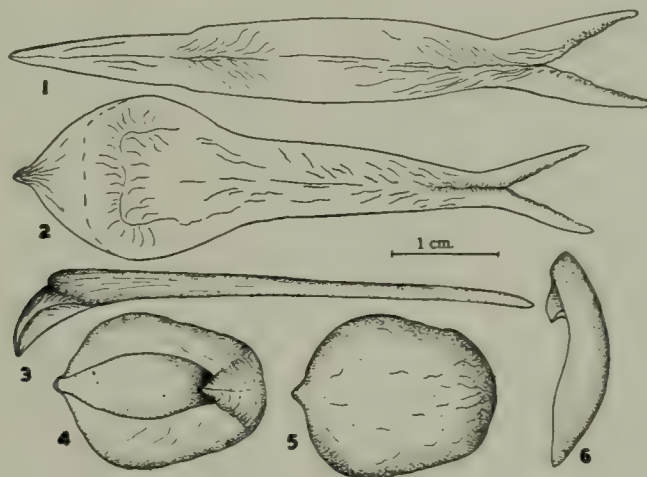


Plate 80. Accessory plates of *Parapholas acuminata* Sowerby. Fig. 1. Hypoplax showing the forked posterior end and the pointed anterior end. Fig. 2. Dorsal view of the metaplast showing the broad anterior end which bends sharply downward and comes to a point. Fig. 3. Side view of the metaplast showing the anterior end sharply bent downward to fit against the posterior end of the mesoplast. Fig. 4. Ventral view of the mesoplast of an adult specimen. Fig. 5. Dorsal view of the mesoplast showing the rounded posterior margin and the central point on the anterior margin. Fig. 6. Side view of the mesoplast.

Figs. 1-3. From Panama Bay, Panama. Figs. 4-6. From Mazatlan, Mexico.

## *Parapholas calva* Sowerby

### Plate 81

*Pholas calva* 'Gray' Sowerby 1834, Proceedings Zoological Society London, p. 69 (Perico Island, Panama Bay); Sowerby 1849, Thesaurus Conchyliorum **2**, p. 493, pl. 105, figs. 51-53; Sowerby 1849 [1850], Proceedings Zoological Society London, p. 162, pl. 5, fig. 4.

*Pholas calva* var. *nana* Sowerby 1834, Proceedings Zoological Society London, p. 70 (Panama).

*Parapholas bisulcata* Conrad 1849, Proceedings Academy Natural Sciences Philadelphia **4**, p. 156 (Lower California and Peru); Conrad 1850, Journal Academy Natural Sciences Philadelphia **1**, pt. 4, p. 279, pl. 39, fig. 5 [not fig. 4 as given in the text].

*Martesia calva* Sowerby, Gray 1851, Annals and Magazine Natural History (2) **8**, p. 383.

*Parapholas calva* Sowerby, Carpenter 1855, Catalogue of the Reigen Collection of Mazatlan Mollusca, p. 9; Hertlein and Strong 1950, Zoologica **35**, p. 249.

*Distinctive characters.* Shell about  $1\frac{3}{4}$  inches in length. Mesoplast greatly enlarged, completely covering the beaks anteriorly and extending posteriorly in two lobes on either side of the metaplast. Metaplast and hypoplax forked posteriorly. Chitinous plates on the posterior slope rounded.

*Description.* Shell reaching 44 mm. (about  $1\frac{3}{4}$  inches) in length and 25 mm. (1 inch) in height, white to light brown in color, pear-shaped in outline, rather light in structure and producing a callum in the adult stage. Immature specimens beaked and widely gaping anteriorly and tapering posteriorly to a narrowly rounded posterior margin. Shell divided into three well defined areas. Anterior portion rather small, sculptured by close-set, low, upturned concentric ridges and weak radial ribs. Anterior slope separated from the disc by a narrow and lightly impressed umbonal-ventral sulcus. Disc sculptured by close-set growth lines and separated from the posterior slope by a slight groove extending from the umbos to the posterior ventral margin. Posterior slope covered with a series of rounded, overlapping chitinous plates. In the adult the pedal gape is closed by a thin but strong callum, only a narrow slit remaining when the callum is complete. Callum sculptured with very fine growth lines and faint parallel ridges which are the extensions of the radial ribs. The callum does not extend dorsally between the beaks. Mesoplax greatly enlarged in the adult, extending anteriorly to cover the beaks completely. It is also produced posteriorly into two lobes which extend backward on either side of the metaplax. The mesoplax of young specimens is unknown. Metaplax long and narrow, pointed anteriorly, tapering and divided posteriorly. Hypoplax pointed anteriorly, divided posteriorly. Siphonoplax lacking. Chimney, according to the figure given by Sowerby (1849), extending anteriorly well over the surface of the shell at least as far as the umbonal-ventral ridge. Periostracum dark brown in color, heavy on the disc, and produced as overlapping plates on the posterior slope.

It is impossible to describe the interior of the shell as the few specimens available were intact and to remove the accessory plates and separate the valves seemed unwise. Nothing is known of the soft parts of this species.

length	height	ratio h:l	
49.5 mm.	24.5	2.0	Manta Bay, Ecuador
48.0	24.0	2.0	" " "
44.0	25.0	1.7	Mazatlan, Mexico

*Types.* The holotype of *Parapholas calva* Sowerby is in the British Museum according to a letter received from G.L. Wilkins: the type locality is Perico Island, Canal Zone, Panama Bay. The location of the holotype of *Parapholas bisulcata* Conrad is unknown.

*Remarks.* *Parapholas calva* Sowerby is apparently a very rare species to judge by the very few published records and the lack of specimens in collections. It is close in its relationship to *P. acuminata* Sowerby, but may be distinguished from this species by its much larger and lobed mesoplax, and its rounded, rather than angled posterior margin. It is also closely related to *Parapholas branchiata* Gould, a West African species which has a similarly lobed dorsal plate (see Nicklès, 1953, Institut Royal des Sciences Naturelles de Belgique 39, no. 13, p. 10, pl. 1, figs. 10-13).

In the original description of this species Sowerby states that the specimens were taken from *Spondylus* from the Isle of Perico, Bay of Panama in 12 fathoms and the young specimens were taken from hard stone at low water. In the Thesaurus Conchyliorum, however, he does not mention the *Spondylus* and though he does not correct this statement, it seems probable that it was in error; at least this would be a most unusual substratum for a *Parapholas*. No other species in this genus bores into other shells and the

specimens Sowerby figures are much too large to be shell-borers. Carpenter (1855, loc. cit.) was probably dealing with two species under this name, but without seeing the specimens with which he was working it is impossible to say definitely.

*Range.* From Ensenada de San Francisco, Guaymas, Sonora, Mexico to Manta Bay, Ecuador.

*Specimens examined.* MEXICO: Ensenada de San Francisco, Guaymas, Sonora (Hancock Foundation); Mazatlan (MCZ). ECUADOR: Manta Bay in 1 fathom (Hancock Foundation).

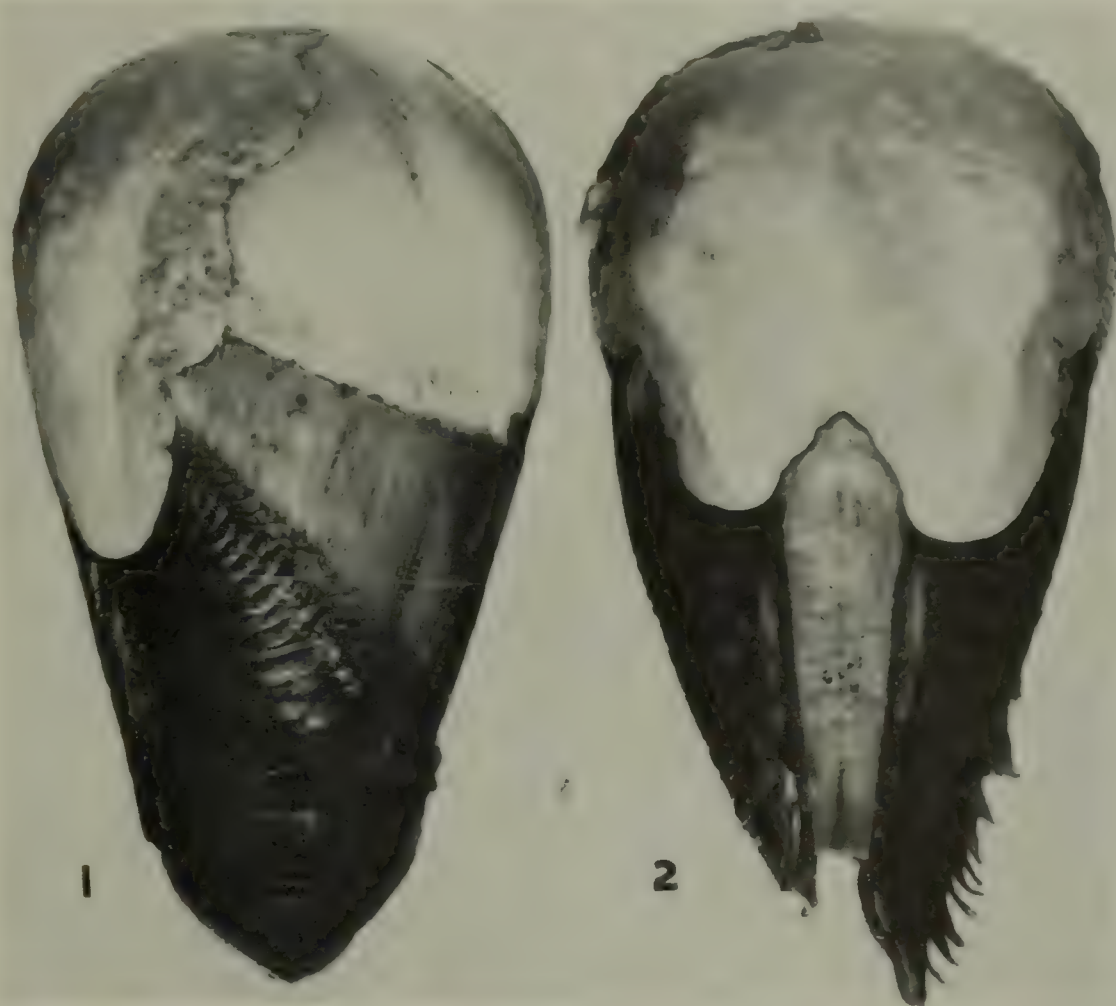


Plate 81. *Parapholas calva* Sowerby. Mazatlan, Mexico. Fig. 1. Side view showing the rounded plates on the posterior slope. Fig. 2. Dorsal view showing the lobed mesoplax (about  $2\frac{1}{2}x$ ).

### Subfamily Jouannetiinae

#### Genus *Jouannetia* des Moulins

*Jouannetia* des Moulins 1828, Bulletin d'Histoire Naturelle Société Linnéenne, Bordeaux 2, p. 244 (genotype, *Jouannetia semicaudata* des Moulins, monotypic).

*Jouannetia* Gray 1840, Synopsis Contents British Museum, ed. 42, p. 154 (emendation for *Jouannetia*).

Adult shell white to dirty gray-brown in color, globose, inequivalve, with a large protruding callum and no apophyses. In the young stage the shell is equivalved, beaked, widely gaping anteriorly and closed posteriorly. Anterior portion sculptured with numerous close-set, imbricated ridges and usually weak radial ribs which are indicated by the radial arrangement of the imbrications. Umbos prominent and in young specimens more

or less centrally located. Posterior slope sculptured with concentric growth lines and thin elevated ridges. In the adult the right valve elongates, producing a siphonoplax which may be pectinate or smooth. Callum greatly produced giving the adult shell a globose appearance. On the right valve it is normal, while on the left it is greatly enlarged and overlaps the right valve. The callum extends dorsally between the beaks and that of the left valve forms the covering for the anterior adductor muscle. Interior of the shell white and glazed. Umbonal-ventral sulcus expressed internally as a weak to strong rib. Shell with or without special laminae for the attachment of the posterior adductor muscle.

On the basis of shell characters the genus *Jouannetia* des Moulins is most closely related to *Nettastomella* Carpenter. The young shells of the two genera are almost inseparable, having a similar type of sculpture, umbonal reflection, pedal gape and umbonal-ventral sulcus. Both lack the apophyses, and the type of siphonoplax is similar even though restricted to a single valve in *Jouannetia*. The outstanding difference between the two is the great production of the callum in *Jouannetia*.

The type of *Jouannetia* is a Tertiary fossil from the shell marls of Merignac near Bordeaux, France. The specimens, which were taken from coral, are unusually well preserved and show all the characteristics of the genus including the special laminae for the attachment of the posterior adductor muscle. The most closely related living species, *Jouannetia cumingii* Sowerby, from the Indo-Pacific, also bores into coral and soft coral-line rock.

Sieverts (1933) reviewed the genus particularly as regards the fossil forms, recording 27 species, only 8 of which are recent. Of these eight, however, one is a synonym and two are of doubtful value. She stated that the genus occurred as far back as the Upper Cretaceous and was world-wide in distribution. Recent species, except for *J. vignoni* Fischer from Gabon, West Africa, and *J. quillengi* Turner from the Western Atlantic are restricted to the Pacific.

Very little is known concerning the biology of this group. Fischer (1860, 1862) described and figured the general morphology of *J. cumingii* Sowerby and *J. globosa* Sowerby (= *J. globulosa* Quoy and Gaimard). These descriptions, based upon preserved material, show the basic resemblance of this group to the other members of the Pholadidae. A well illustrated account of the morphology of *J. cumingii* Sowerby by E. Egger (1887) considers in detail the various systems of this species. However, though this species is not excessively rare, as are most in this genus, nothing is known of its life history. So far as is known all species are coral and rock-borers.

Genotype, *Jouannetia semicaudata* des Moulins, monotypic.

The genus *Jouannetia* is divided into two subgenera and these may be keyed as follows:

- Shell with special laminae for the attachment of the posterior adductor muscle. Margin of the siphonoplax smooth . . . . *Jouannetia* s.s.
- Shell without special laminae for the attachment of the posterior adductor muscle. Margin of the siphonoplax pectinate . . . *Pholadopsis*

### Subgenus *Jouannetia* des Moulins

*Jouannetia* des Moulins 1828, Bulletin d'Histoire Naturelle Société Linnéenne, Bordeaux 2, p. 244.

The species included in the subgenus *Jouannetia* are characterized by having special laminae projecting inwardly from the posterior portion of the valves for the attachment

of the posterior adductor muscle, and in having the posterior margin of the siphonoplax smooth.

There are only two living species in this subgenus: *J. cumingii* Sowerby from the Indo-Pacific and *J. duchassaingi* Fischer from the Eastern Pacific.

Subgenotype, *Jouannetia semicaudata* des Moulins, monotypic.

***Jouannetia* (*Jouannetia*) *duchassaingi* Fischer**

Plate 82

*Jouannetia duchassaingi* 'Deshayes' Fischer 1862, Journal de Conchyliologie **10**, pp. 375-376, pl. 15, fig. 3 (Panama).

**Distinctive characters.** Shell reaching about 2 inches in length, having the callum longitudinally striated, the posterior margin of the siphonoplax smooth, and having special laminae for the attachment of the posterior adductor muscle.

**Description.** Shell white, globose, solid, reaching 50 mm. (about 2 inches) in length and 41 mm. (about 1½ inches) in height and having a callum in the adult stage. Young shells nearly equivalved and widely gaping. Valves divided into two areas by an umbonal-ventral sulcus which is very narrow on the right valve but wide on the left valve. Anterior portion triangular in outline and sculptured by close-set concentric ridges and radial ribs which are most clearly marked near the dorsal margin. Posterior area sculptured with fine concentric ridges. Umbos prominent, located near the center of the dorsal margin. Pedal gape closed in the adult by a thick, striated callum which extends dorsally over the beaks and covers the anterior adductor muscle. Siphonoplax produced on the right valve only. It is broad at the base and tapers to a narrowly rounded smooth extremity. Interior of the valve smooth, umbonal-ventral sulcus expressed internally as a rib. Just posterior to the sulcus there is a large lamina or shelf which forms the attachment area for the posterior adductor muscle. A large shield over the umbos forms the attachment area of the anterior adductor muscle.

The soft parts of this species are unknown.

length	height	ratio h:l	
50 mm.	41 mm.	1.2	Holotype

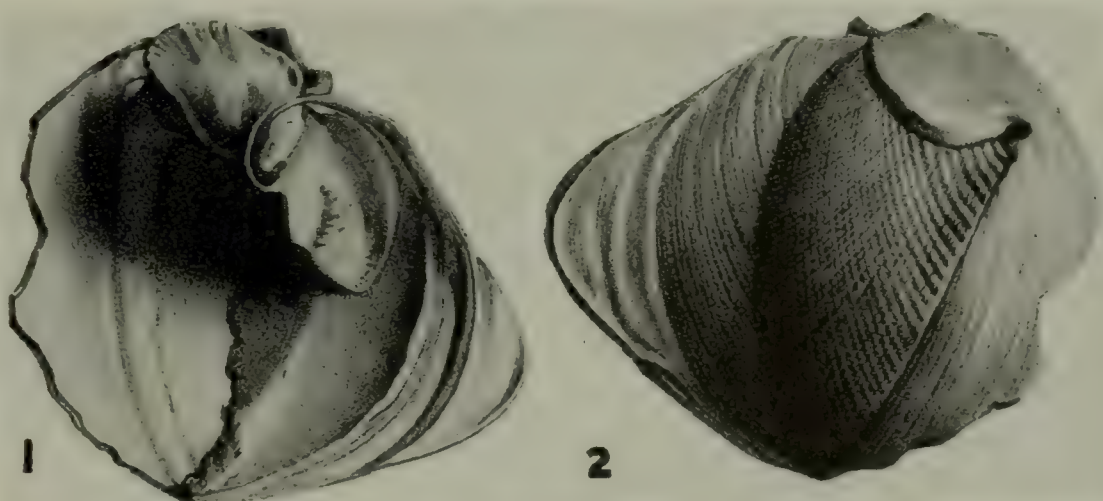


Plate 82. *Jouannetia duchassaingi* Fischer. Figs. 1-2. Holotype (after Fischer, Journal de Conchyliologie **10**, pl. 15, figs. 3a-b). Fig. 1. Internal view of right valve showing the umbonal reflection and the large shelf for the attachment of the posterior adductor muscle. Fig. 2. External view of the right valve showing the smooth, triangular siphonoplax, the sculptured callum, and the extension of the callum over the dorsal surface of the shell.

*Types.* The type of *Jouannetia duchassaingi* Fischer was in the collection of Deshayes and, according to Sherborn, is now probably in the British Museum. The type locality is Panama (west coast).

*Remarks.* Until recently this species was known only from the original specimen and description. Dr. A. A. Olsson, however, obtained it on a recent trip to Ecuador. His specimens from Manta were beach worn, but probably had been boring in the shelving ledges of shale which extend to the west of the city. This species is most closely related to *J. cumingii* Sowerby but differs from it by being much larger and having the callum longitudinally striated.

*Range.* From Panama south to Manta, Ecuador.

*Specimens examined.* ECUADOR: Manta (A. A. Olsson).

### Subgenus *Pholadopsis* Conrad

*Pholadopsis* Conrad, June 1849, Proceedings Academy Natural Sciences Philadelphia **4**, p. 156 (genotype, *Pholadopsis pectinata* Conrad, monotypic); Conrad 1850, Journal Academy Natural Sciences Philadelphia (2) **1**, p. 279; Tryon 1862, Proceedings Academy Natural Sciences Philadelphia, p. 216.

*Triumphalia* Sowerby 1849, Thesaurus Conchyliorum **2**, pt. 10, p. 500 (genotype, *Triumphalia globosa* Sowerby [= *P. globulosa* Quoy and Gaimard], subsequent designation, Stoliczka 1870); Sowerby 1849 [1850] Proceedings Zoological Society London, p. 160.

*Triumphala* 'Sowerby' Clessin 1892, Conchylien-Cabinet **11**, part 4, p. 35 [error for *Triumphalia* Sowerby].

The species included in the subgenus *Pholadopsis* Conrad are characterized by having the siphonoplax pectinate and by having the posterior adductor muscle inserted in the normal position. In addition, there is a small mesoplax which in the adult form is fused to the callum.

This subgenus has been referred to by numerous authors as *Triumphalia* Sowerby; however, as a footnote to his original description, Sowerby mentions the genus *Pholadopsis* and states that it may be identical with *Triumphalia*. Consequently, though both Conrad's and Sowerby's work appeared in 1849, there seems little doubt as to which name has priority. Lamy (1926) curiously uses *Triumphalia* rather than *Pholadopsis*, but when considering the species included in the subgenus, he places *pulcherrima* Sowerby in the synonymy of *pectinata* Conrad. These two species were described by Sowerby and Conrad at the same time as their respective genera. Recent workers following Lamy have given priority to Sowerby for the genus and to Conrad for the species.

All four species in this subgenus are exceedingly rare. Each is very distinctive and easily identified. There is one species in each of the four major oceanic divisions: *J. globosa* Sowerby in the Indo-Pacific; *J. pectinata* Conrad in the Eastern Pacific; *J. quil-lingi* Turner in the Western Atlantic, and *J. vignoni* Fischer in the Eastern Atlantic. This last-named species from Gabon, West Africa is known only from the original description and figures (Fischer 1862, Journal de Conchyliologie **10**, p. 276, pl. 15, fig. 4). It has not been found since and the location of the types is unknown. However, the figures are excellent and there is no question as to the uniqueness of this species.

Subgenotype, *Pholadopsis pectinata* Conrad, monotypic.

**Jouannetia (Pholadopsis) pectinata Conrad****Plate 83**

*Pholadopsis pectinata* Conrad, June 1849, Proceedings Academy Natural Sciences Philadelphia 4, p. 156 (Baja California and Peru); Conrad 1850, Journal Academy Natural Sciences Philadelphia (2) 1, p. 279, pl. 39, fig. 3.

*Triumphalia pulcherrima* Sowerby 1849, Thesaurus Conchyliorum 2, pt. 10, p. 501, pl. 106, figs. 58-59 (in soft rock at low water, West Colombia); Sowerby 1849 [1850], Proceedings Zoological Society London for 1849, p. 161, pl. 5, figs. 2a-d.

*Jouannetia pectinata* Conrad, Gray 1851, Annals Magazine Natural History (2) 8, p. 383.

*Jouannetia (Pholadopsis) pectinata* Conrad, Tryon 1862, Proceedings Academy Natural Sciences Philadelphia 15, p. 216.

*Jouannetia (Triumphalia) pectinata* Conrad, Lamy 1926, Journal de Conchyliologie 69, p. 219; Sieverts 1933, Neues Jahrbuch für Mineralogie, Geologie und Palaeontologie 71, Beilage-Band Abt. B, pt. 2, p. 289; Hertlein and Strong 1950, Zoologica 35, no. 19, p. 248.

**Distinctive characters.** Shell with a greatly produced and irregularly sculptured callum. Posterior slope sculptured with smooth concentric ridges and growth lines. Posterior margin of the siphonoplax finely pectinate.

**Description.** Adult shell pear-shaped in outline, inequivalve, reaching about 51 mm. (about 2 inches) in length and 33 mm. (about  $1\frac{1}{4}$  inches) in height, white in color, thin, fragile, and with a greatly produced callum. Young shell equivalve, beaked and widely gaping anteriorly; closed posteriorly. Shell divided into two distinct parts by a narrow umbonal-ventral sulcus. Anterior portion triangular in outline and sculptured by numerous imbricated, concentric ridges and radial ribs. There is a marked constriction of the shell at the umbonal-ventral sulcus. Sulcus narrow and sculptured with concentric ridges and growth lines. Posterior margin of the sulcus indefinite, especially on the right valve. Posterior slope sculptured with concentric ridges and growth lines. Umbos prominent and located near the center of the dorsal margin. Umbonal reflection narrow, free and high. Pedal gape closed in the adult shell by a callum which is nearly typical on the right valve but greatly enlarged on the left valve so that it overlaps the right valve. The callum extends dorsally between the beaks and the left valve enlarges to form the covering of the anterior adductor muscle. Ventrally the callum of the right valve stops at the

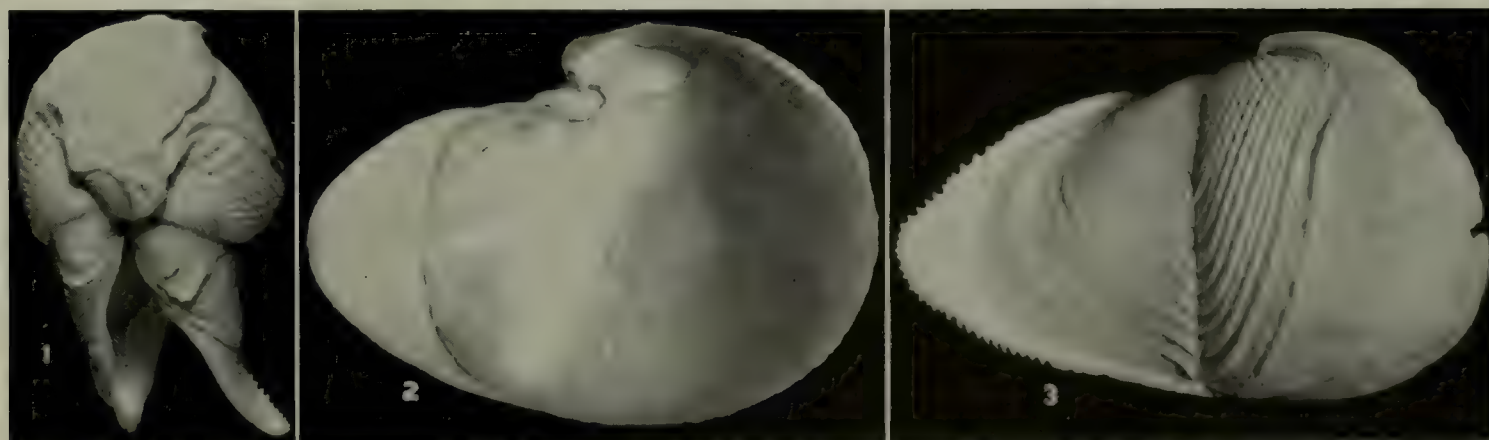


Plate 83. *Jouannetia pectinata* Conrad. Fig. 1. Dorsal view of the paratype showing the greatly enlarged, overlapping callum, the small mesoplax which has been displaced by the growth of the callum, and the pectinate siphonoplax of the right valve. Fig. 2. Internal view of the left valve of the holotype showing the tremendous callum, the small posterior adductor muscle scar, the small chondrophore and the lack of the apophysis. Fig. 3. External view of the right valve of the holotype showing the much smaller callum of this valve and the pectinate siphonoplax (all  $1\frac{1}{3}x$ ).

umbonal-ventral sulcus but on the left valve additional material is added along the ventral and posterior margins of the posterior slope. Right valve elongated posteriorly, forming the siphonoplax which is broad at the base and tapers to a narrowly rounded, finely pectinate posterior margin. Mesoplax small, triangular and sculptured with concentric growth lines. In the adult shell it is fused to the callum, and the enlarging of the callum displaces it so that it is set at an angle to the longitudinal axis of the shell.

Interior of the shell white and glazed. Umbonal-ventral sulcus expressed internally as a ridge. Anterior adductor muscle scar covering the umbonal reflection. Posterior adductor muscle scar small, elongate-oval, and located high on the posterior slope. Pallial sinus profound, extending anterior to the umbonal-ventral ridge. Chondrophore on the left valve small. The soft parts of this species are unknown.

length *	height	ratio h:l	
51.5 mm.	33.5 mm.	1.5	Holotype
41.5	28.5	1.4	Paratype
28.0	21.5	1.3	Port Parker, Costa Rica

\* The measurements are for entire adult specimens including the callum and the siphonoplax.

*Types.* The holotype of *Pholadopsis pectinata* Conrad is in the Academy of Natural Sciences Philadelphia, no. 51075. The type locality as restricted by Hertlein and Strong (1950) is the east coast of Baja California. The type of *Triumphalia pulcherrima* Sowerby is in the British Museum; the type locality is West Columbia.

*Remarks.* *Jouannetia pectinata* Conrad is a very distinctive species readily distinguished from all others in this subgenus by its large size, its fragile shell and its greatly enlarged, irregularly sculptured callum. It is most closely related to *J. quillengi* Turner of the Western Atlantic. See Remarks under *quillengi*. It is also closely related to *J. globulosa* Quoy and Gaimard from the Indo-Pacific. This latter is a much smaller species with a broad umbonal-ventral sulcus and a globose rather than pear-shaped outline in the adult stage. From *J. vignoni* Fischer of West Africa it differs by its much larger size and proportionately much smaller siphonoplax. In addition, the siphonoplax of *J. vignoni* has a few broad, coarse pectinations while those of *J. pectinata* are numerous and small. Specimens of *J. pectinata* reach 50 mm. in length while those of *J. globulosa* average 23 mm. and the type of *J. vignoni* is 10 mm. in length. However, in this group as well as all members of the Pholadidae, size alone should not be depended upon as a criterion for separating species.

Nothing is known of the biology of this rare species. The specimens collected by Dr. Thomas B. Wilson and sent to the Academy of Natural Sciences, Philadelphia were alive when collected and were probably taken in the intertidal zone. The specimens collected by Hugh Cuming were in soft stone at low water.

*Range.* From Cedros Island, Baja California south to Peru (Conrad, 1849).

*Specimens examined.* MEXICO: Baja California (ANSP). Eight miles west of Cedros Island (N. Lat. 28°05'; W. Long. 115°31') in 64 fathoms (Hancock Foundation). COSTA RICA: Port Parker (California Acad. Sci.). ECUADOR: South of Punta Santa Elena (S. Lat. 2°12'; W. Long. 81°00') (Hancock Foundation).

**Jouannetia (Pholadopsis) quillingi**, new species

## Plate 84

*Distinctive characters.* Shell with a large and irregularly sculptured callum. Posterior slope with high, thin, concentric ridges bearing recurved spines. Siphonoplax small and with few, spine-like pectinations.

*Description.* Adult shell nearly globular in outline, inequivalve, reaching about 21 mm. (about  $\frac{7}{8}$  of an inch) in length and 15 mm. (about  $\frac{5}{8}$  of an inch) in height, white in color, thin, fragile and with a greatly produced callum. Young shells equivalve, beaked and widely gaping anteriorly and closed posteriorly. Valves divided into two distinct parts by the umbonal-ventral sulcus. Anterior portion triangular in outline and sculptured with numerous laminated, imbricate, concentric ridges and weak radial ribs which are indicated only by the radial arrangement of the imbrications. There is a marked constriction of the shell at the umbonal-ventral sulcus. The sulcus itself is very narrow and appears only as the line of constriction of the shell. Posterior slope sculptured with thin, raised, concentric ridges and growth lines. The ridges are scalloped and on perfect specimens bear long recurved spines. Umbos prominent and located near the anterior third of the specimen. Umbonal reflections narrow, free and raised well above the surface of the shell. Pedal gape closed in the adult shell by a callum which is nearly typical on the right valve but is enlarged on the left valve so that it overlaps the right valve. The callum extends dorsally between the beaks and on the left valve is enlarged to form the covering for the anterior adductor muscle. Ventrally the callum of the right valve stops at the sulcus, while on the left valve, additional material is added along the ventral and posterior margin of the posterior slope. Right valve slightly elongate posteriorly, forming the small siphonoplax which is strongly pectinate on its posterior margin. There are fifteen strong, spine-like pectinations on the holotype. Mesoplax small, wedge-shaped and sculptured with strong, chevron-shaped growth lines. The enlarging of the callum displaces the mesoplax in the adult so that it is set at an angle to the longitudinal axis of the shell.

Interior of the shell white and glazed. Umbonal-ventral sulcus expressed internally as a narrow ridge. Muscle scars barely visible on the specimens examined. Posterior adduc-

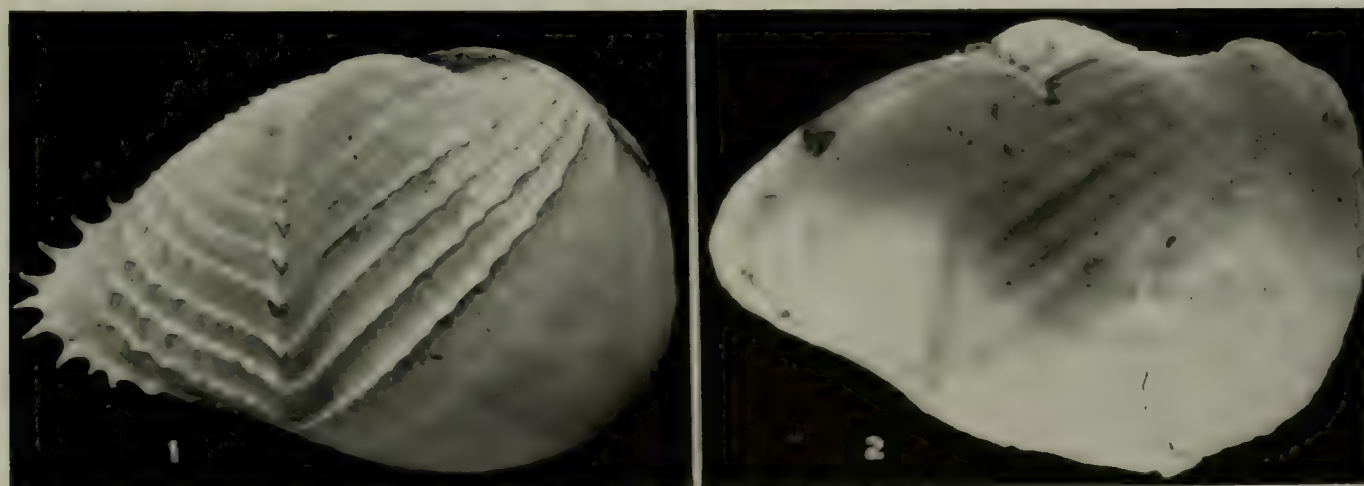


Plate 84. *Jouannetia quillingi* Turner. Holotype from Lake Worth, Florida. Fig. 1. External view of the right valve showing the pectinations on the siphonoplax and the pronounced sculpture of the posterior slope. Fig. 2. Internal view of the left valve showing the small chondrophore and the smooth posterior margin. The dorsal portion of the callum is broken, but in complete specimens it is similar to that shown in plate 83, fig. 2 (about  $2\frac{1}{2}x$ ).

tor muscle scar small, oval in outline and located high on the posterior slope. Anterior adductor muscle scar covering most of the umbonal reflection. Pallial sinus extending anteriorly to the umbonal-ventral ridge. Ligament small and internal. There is a small chondrophore on the left valve. Soft parts of this species are unknown.

length *	height	ratio h:l	
21.5 mm.	15.5 mm.	1.38	Holotype
16.5	14.0	1.18	Pawleys Island, South Carolina
9.0	5.5	1.60	off Cape Fear, North Carolina

\* The measurements are for entire adult specimens including the callum and the siphonoplax.

*Types.* The holotype from the north end of Lake Worth Inlet, Lake Worth, Florida is in the Museum of Comparative Zoölogy, no. 189913. Paratypes are in the collection of Tom and Paul McGinty, Boynton Beach, Florida. The types were collected by Paul McGinty and Ben Quilling. We take pleasure in naming this species for Mr. Quilling.

*Remarks.* This is the first record for the genus *Jouannetia* in the Western Atlantic. This new species is close in its relationship to *J. pectinata* Conrad of the Eastern Pacific but may be readily distinguished from it by its much smaller size, by the pronounced, spiny sculpture on its posterior portion and by the relatively few large pectinations on the siphonoplax. From *J. vignoni* Fischer of West Africa it is differentiated by its short, broad siphonoplax which makes the right valve only slightly longer than the left in adult specimens. In *J. vignoni* the siphonoplax is long and narrow, the right valve of the adult specimen being nearly twice the length of the left valve. In addition, the pectinations on the siphonoplax of *vignoni* are broad and coarse while those of *quillingi* are long and spine-like.

Little is known of the ecology of this species. The McGintys have written that they found it "living in a large piece of submerged and rotted wood." In 1885 the *Albatross* obtained specimens while dredging in 18 fathoms off Cape Fear, North Carolina: however, no record was made as to whether the specimens were living or dead, or in what they were found. At Pawleys Island, South Carolina, this species was apparently living in the intertidal zone.

Woodring (1925, Miocene Mollusks from Bowden, Jamaica, p. 193, pl. 26, figs. 13-15) describes a *Jouannetia sphaeroidalis* Guppy MS. In his remarks Woodring states that if this is a *Jouannetia* the specimens are young because there is "... no trace of a posterior appendage on the right valve." At the same time he describes the anterior callus or callum which would indicate that they were not young. At the time the callum is produced, all other adult features are also added, a condition which exists throughout all of the Pholadidae. Therefore, from the description and figures of Woodring, it seems clear that this is not a *Jouannetia*. It is perhaps a *Diplothyra*.

*Range.* From off Cape Fear, North Carolina south to Lake Worth, Florida.

*Specimens examined.* NORTH CAROLINA: *Albatross*, station 2615, 27 miles east southeast of Cape Fear (N. Lat. 33°45': W. Long. 77°25') in 18 fathoms; *Albatross*, station 2161, 25 miles east southeast of Cape Fear (N. Lat. 33°42': W. Long. 77°31') in 17 fathoms (both USNM). SOUTH CAROLINA: Pawleys Island (Charleston Museum). FLORIDA: North end of Lake Worth Inlet, Lake Worth, Florida (T. McGinty); off Naples in 4 to 6 fathoms (T. L. Moise).

Genus *Nettastomella* Carpenter

*Netastoma* Carpenter 1864, Report British Association Advancement of Science for 1863 [1864], p. 637 (genotype, *Netastoma darwinii* 'Sowerby' Carpenter); non *Nettastoma* Rafinesque 1810.

*Nettastomella* Carpenter 1865, Proceedings Zoological Society London, p. 202 [new name for *Netastoma* Carpenter; non *Nettastoma* Rafinesque]; Hertlein and Strong 1950, *Zoologica* **35**, p. 247.

*Netastomella* 'Carpenter' Paetel 1875, Familien-und Gattungsnamen der Mollusken, Berlin, p. 138 [error for *Nettastomella* Carpenter].

*Nettastoma* 'Carpenter' Lamy 1926, *Journal de Conchyliologie* **69**, p. 155 [error for *Netastoma* Carpenter].

Shell small to moderate in size, gaping widely anteriorly, the pedal gape not closed in the adult stage by a calcareous callum. In adult specimens a narrow band of calcareous material is laid down anterior to the imbricated area and this may be fluted or simply marked by growth lines. A chitinous callum covers the remainder of the pedal gape with only a minute central pore remaining open. The foot atrophies in the adult. Umbonal reflection sculptured or smooth, simple, narrow and free for most of its length. Dorsal plates lacking, siphonoplax short and widely diverging or long and acuminate. Apophyses lacking.

At the time Carpenter described his genus *Netastoma* he was working with the fauna of the west coast of North America and incorrectly determined young specimens of *N. rostrata* Valenciennes as *N. darwinii* Sowerby. This was an easy error to make as young specimens of *N. rostrata*, when they first begin to produce the siphonoplax and before they have begun to elongate it, look much like specimens of *N. darwinii* as illustrated by Sowerby, though they are much smaller. However, adult specimens of *rostrata* are not only smaller in size but eventually produce a long, acuminate siphonoplax, while the South American species produces short, greatly thickened and widely diverging outgrowths on the posterior margin of the shell.

Through the kindness of Dr. Katherine VanWinkle Palmer we have been able to examine specimens from the Carpenter Collection now in the Redpath Museum, McGill University, Montreal, Canada. In this collection there are four lots of *Nettastomella rostrata* Valenciennes all labeled in Carpenter's own hand as *Nettastomella darwinii* Sowerby. Consequently, there seems to be little doubt as to Carpenter's confusion regarding these two species. In his brief description of the genus, Carpenter refers to the strong "frills" on the posterior portion of the shell and to the valves being "prolonged, like duck's bill." This applies exactly to *rostrata*, the West Coast species, while on *darwinii* Sowerby the posterior slope is marked only by low, indistinct ridges and growth lines and the siphonoplax is short and diverging. It seems logical, therefore, even though *darwinii* remains in this genus, that the type of *Nettastomella* becomes *N. darwinii* 'Sowerby' Carpenter (= *rostrata* Valenciennes); non *darwinii* Sowerby.

Only two species are known in this genus: *N. rostrata* Valenciennes, occurring along the California coast and *N. darwinii* Sowerby which is restricted to Chile, Argentina and Uruguay.

Genotype, *Netastoma darwinii* 'Sowerby' Carpenter 1864 (= *N. rostrata* Valenciennes), monotypic; non *Pholas darwinii* Sowerby 1849).

Key to the species of *Nettastomella*

1. Shell small, never over an inch in length (not including the siphonoplax), siphonoplax in adult specimens long and thin, not diverging . . . . . *N. rostrata*
2. Shell large, reaching  $1\frac{1}{2}$  inches in length, siphonoplax heavy, short and widely diverging . . . . . *N. darwinii*

***Nettastomella darwinii* Sowerby**

Plates 85–86

*Pholas darwinii* Sowerby 1849, Thesaurus Conchyliorum **2**, part 10, p. 490, pl. 107, figs. 76–77 (Chiloe [Island, Chile], C. Darwin, collector); Sowerby 1873, Conchologica Iconica **18**, pl. 4, fig. 12. [Not described in the Proc. Zool. Soc. London 1849 as indicated in the Thesaurus.]

*Pholadidea (Nettastomella) darwinii* Sowerby, Oldroyd 1924, Stanford University Publications, University Series, Geological Sciences **1**, p. 213, pl. 42, figs. 7–8; A. Carcelles 1950, Anales del Museo Nahuel Huapi **2**, p. 82, pl. 5, fig. 93.

**Distinctive characters.** Shell 1 to  $1\frac{1}{2}$  inches in length, very widely gaping anteriorly, closed posteriorly and having a short, heavy, widely diverging siphonoplax. Callum existing as a narrow band which is devoid of sculpture. Sculpture on the posterior slope consisting of low concentric ridges and growth lines.

**Description.** Shell reaching 37 mm. (about  $1\frac{1}{2}$  inches) in length and 21 mm. (about  $\frac{7}{8}$  of an inch) in height, white, rather light in structure, beaked anteriorly and widely gaping; closed posteriorly. Adult with a partial callum and a short, heavy, widely diverging siphonoplax. Valves divided into two areas by a marked umbonal-ventral constriction though no true sulcus is formed. Anterior portion triangular in outline and sculptured with thin, high, concentric ridges and weak radial ribs. Posterior portion sculptured only with low ridges and growth lines. Umbos prominent and located near the anterior third of the shell. Umbonal reflection narrow and free. Callum in the adult specimen existing as a narrow band of unsculptured calcareous material extending along the anterior margin and dorsally over the beaks to the umbo. Siphonoplax short, calcareous, solid in structure and widely diverging. So far as known there are no other accessory plates.

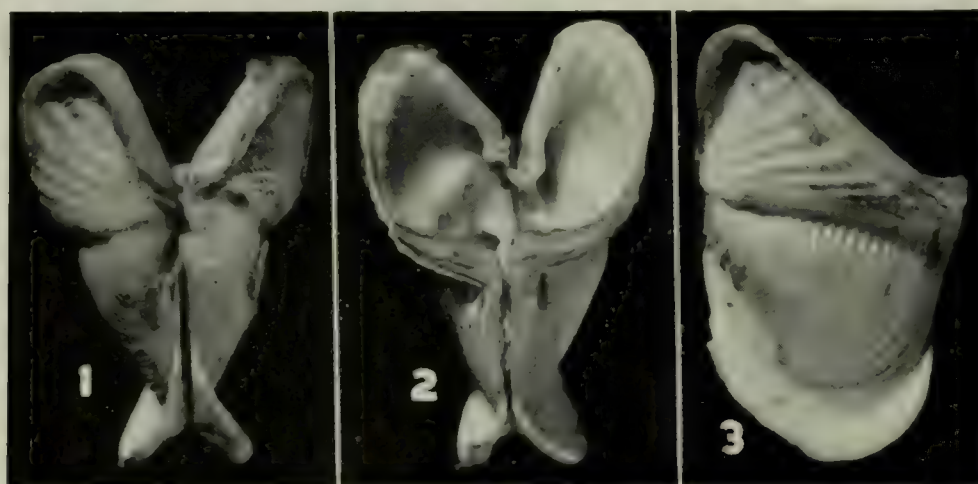


Plate 85. *Nettastomella darwinii* Sowerby. Figs. 1–3. Holotype of *Pholas darwinii* Sowerby (= *Nettastomella darwinii* Sowerby). Chiloe Island, Chile. Fig. 1. Dorsal view showing the umbonal reflection and the dorsal extension of the callum. Fig. 2. Ventral view showing the chondrophore. Fig. 3. Side view showing the narrow band of the calcareous portion of the callum (all 2x).

Photographs received through the kindness of Mr. G. L. Wilkins, British Museum (Natural History).

Interior of shell white and glazed. Muscle scars well marked; pallial sinus not evident in the few specimens examined. Apophyses lacking. Chondrophore small. Preserved material being unavailable, it is impossible to state whether or not the remainder of the pedal gape is closed by a chitinous callum.

length	height	ratio h:l	
37.0 mm.	21.0 mm.	1.7	Piriapolis, Maldonado, Uruguay
35.0	21.0	1.6	“ “ “
35.0	22.0	1.5	Comodoro, Rivadavia, Chubut, Argentina

*Types.* The holotype of *Pholas darwinii* Sowerby is in the British Museum (Natural History). The type locality is Chiloe Island, Chile, C. Darwin collector.

*Remarks.* *Nettastomella darwinii* Sowerby is apparently a very rare species and has been confused with *N. rostrata* Valenciennes from the coast of California, probably because of the early use of this name for the Californian species by P. P. Carpenter. However, *N. darwinii* can readily be told from *N. rostrata* by its larger size, its relatively smooth posterior portion and callum, and its short, heavy, widely diverging siphonoplax.

*Range.* From Maldonado, Uruguay south to Chubut, Argentina and north along the coast of Chile to Chiloe Island.

*Records.* URUGUAY: Piriapolis, Maldonado (A. Carcelles). ARGENTINA: Zona Militar de Comodoro Rivadavia (A. Carcelles); Mar del Plata (USNM). CHILE: Canal de Chacao, north end of Chiloe Island in 22 fathoms (Univ. of Lund Exped.).

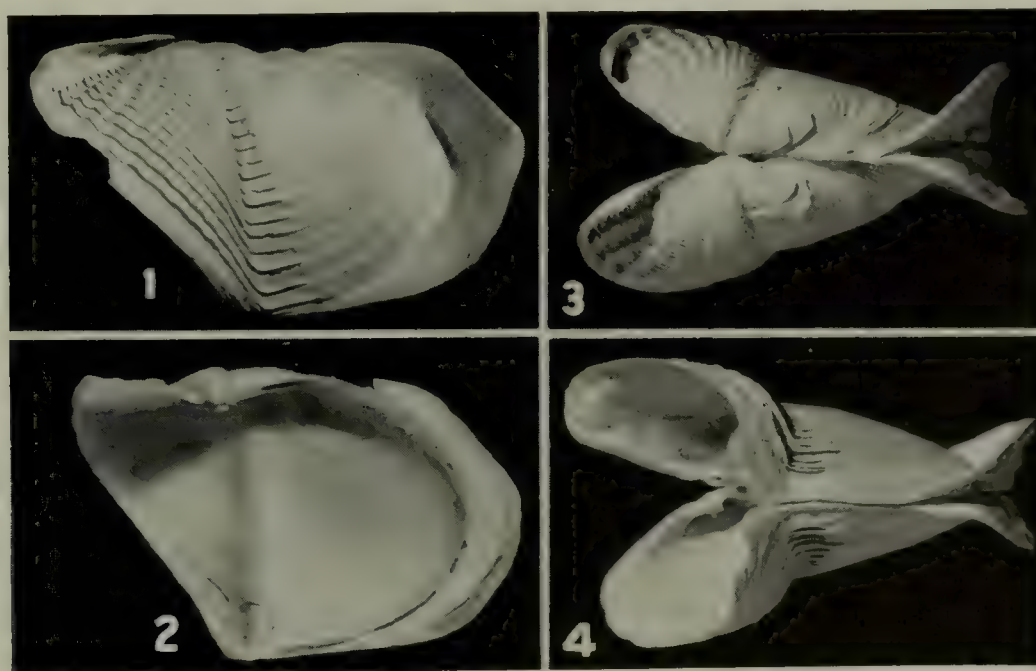


Plate 86. *Nettastomella darwinii* Sowerby. Figs. 1, 3 and 4. Zona Militar de Comodoro Rivadavia, Argentina. Fig. 2. Piriapolis, Maldonado, Uruguay (all about  $1\frac{1}{2}x$ ).

### *Nettastomella rostrata* Valenciennes

#### Plate 87

*Pholas rostrata* Valenciennes 1846 [in] Abel du Petit-Thouars, Voyage Autour du Monde sur la Frégate La Vénus. Atlas de Zoologie, Mollusques, pl. 24, fig. 4 [name listed on plate; no locality given]; Lamy 1921, Bulletin Muséum National d'Histoire Naturelle, Paris 27, p. 182 (Monterey, California).

*Nettastomella darwinii* 'Sowerby' Carpenter 1865, Proceedings Zoological Society London, p. 202 (Monterey and San Diego [California]; Vancouver [British Columbia]).

*Pholadidea* (*Nettastomella*) *rostrata* Valenciennes, Oldroyd 1924, Stanford University Publications, University Series, Geological Sciences 1, no. 1, p. 213, pl. 13, figs. 10-11, pl. 38, figs. 7, 10.

*Nettastomella rostrata* Valenciennes, Dall 1921, Bulletin 112, United States National Museum, p. 56.

**Distinctive characters.** Shell small,  $\frac{3}{4}$  inch or less in length, widely gaping anteriorly, closed posteriorly and with a long, tapering siphonoplax in the adult stage. Callum existing as a band which is sculptured with high, thin flutes. Sculpture on the posterior slope consisting of thin, high, concentric ridges.

**Description.** Shell small, reaching about 20.1 mm. (about  $\frac{3}{4}$  inch) in length and 7.8 mm. (about  $\frac{1}{4}$  inch) in height, fragile, beaked anteriorly and widely gaping in the young stage; closed posteriorly. In the adult stage there is a long, acuminate siphonoplax. Shell divided into two areas by a marked constriction of the valves, though no true sulcus is formed. Anterior portion triangular in outline and sculptured with numerous, thin, high, concentric ridges and weak radial ribs. Rounded imbrications are formed where the radial ribs cross the ridges. Posterior portion sculptured with high, thin, concentric flutes. Umbos prominent, located near the anterior third of the shell. Umbonal reflection narrow and free. The calcareous portion of the callum exists as a narrow band extending along the anterior margin of the beaks and dorsally over the umbonal reflections to enclose partially the anterior adductor muscle. The callum is very fragile and is sculptured with high, thin flutes. The remainder of the pedal gape is closed by a chitinous covering leaving only a minute central pore open in the fully adult specimen. Siphonoplax varying in length and width depending upon the age of the specimen and the depth to which it is boring. In young specimens it is very short and broad, and may be reflected outwardly, but as the specimen grows older, the siphonoplax elongates, becoming acuminate and often rather irregular in shape. There are no other accessory plates. Interior of the shell white and glazed. Posterior adductor muscle scar large, oval in outline and set high on the posterior slope. Pallial sinus extending anterior to the umbonal-ventral ridge. Apophyses lacking. Siphons slightly papillose at the posterior end, white in color and with a periostracal sheath only at the base. They may be extended a short distance beyond the end of the siphonoplax or contracted completely within the shell. Foot large, round and truncated in young specimens; atrophied in the adult.



Plate 87. *Nettastomella rostrata* Valenciennes. Fig. 1. San Diego, California. Dorsal view showing the extension of the marginal callum over the beaks, the strong sculpture on the posterior slope and the siphonoplax. Fig. 2. San Pedro, California. A small but adult specimen showing the very small anterior portion, the wide band of the callum and the greatly extended siphonoplax. Figs. 3-4. Laguna, California. Fig. 3. Ventral view of a young specimen just beginning to produce the siphonoplax. Fig. 4. Internal view showing the cavity formed by the reflection of the callum over the beaks, and the deep pallial sinus. Fig. 5. San Pedro, California. Side view showing the sculpturing on the callum and the free umbonal reflection (all  $2\frac{1}{2}x$ ).

length	height	ratio h:l	
12.5 mm.*	12.0 mm.	1.0	White Point, San Pedro, California
9.8	8.1	1.2	Laguna, California
9.5	7.9	1.2	San Pedro, California
8.2	5.5	1.4	" " "

\* Not including the siphonoplax

*Types.* According to Lamy 1921, Bulletin Muséum National d'Histoire Naturelle, Paris **27**, p. 182, the type of *P. rostrata* Valenciennes is in the Paris Museum. The type locality, Monterey, California, though not published by Valenciennes, is on the original label.

*Remarks.* *Nettastomella rostrata* Valenciennes is one of the smallest of the rock-boring pholads. It is found in soft shale beds along the California coast. Specimens sent by E. P. Chace were from soft mud-shale blocks brought in near shore at White Point, San Pedro, California; others have been dredged in depths up to 55 fathoms. They are not deep borers and their burrows are seldom perfectly straight. The siphonoplax, following the contours of the burrow, may be very irregular in shape and curvature.

*Nettastomella rostrata* Valenciennes is not closely related to any other species. *N. darwinii*, with which it has been confused, is quite a different species.

*Range.* Puget Sound (Dall 1921) and Vancouver (P. P. Carpenter 1865) south to off Cedros Island, Baja California.

*Specimens examined.* CALIFORNIA: Duxbury Reef, Bolinas (USNM); Monterey (MCZ; Redpath Museum; USNM); off Del Monte, Monterey Bay in 12 fathoms (S. S. Berry); Moss Landing, Monterey Bay in 16 fathoms (MCZ); Santa Barbara (MCZ; Redpath Museum); White Point, San Pedro (E. P. Chace; J. E. Fitch); San Pedro (E. P. Chace; USNM); Long Beach (USNM); Laguna (MCZ); Portuguese Bend (N. Lat.  $33^{\circ}44'$ ; W. Long.  $118^{\circ}22'$ ) (Hancock Foundation); La Jolla (USNM); San Diego (MCZ; Redpath Museum; USNM). MEXICO:  $1\frac{1}{2}$  miles off north end of Cedros Island, Baja California (N. Lat.  $28^{\circ}23'$ ; W. Long.  $115^{\circ}11'$ ) in 55 fathoms (Hancock Foundation).

### Subfamily Xylophaginae

#### Genus *Xylophaga* Turton

*Xylophaga* Turton 1822, Conchylia Insularum Britannicarum, p. 253; Purchon 1941, Journal Marine Biological Association United Kingdom **25**, pp. 1-39.

*Xylotomea* Dall 1898, Transactions Wagner Free Institute of Science, Philadelphia **3**, pt. 4, p. 821 (new name for *Xylophaga* Turton non *Xyloghagus* Meuschen 1778). [This name is unnecessary however, as *Xylophaga* and *Xyloghagus* are not considered homonyms. Meuschen's work has now been rejected by the International Commission—Opinion 260].

*Xilotoma* 'Dall' Gigoux 1934, Revista Chilena de Historia Natural, Santiago **38**, p. 285 (error for *Xylotomea* Dall).

*Protoxylophaga* Taki and Habe 1945, Venus **14**, p. 112 (genotype, *Xylophaga tomlini* Prashad, original designation).

*Neoxylophaga* Taki and Habe 1950, Illustrated Catalogue of Japanese Shells, no. 7, p. 46 (genotype, *Xylophaga rikuzenica* Taki and Habe, original designation).

*Metaxylophaga* Taki and Habe 1950, Illustrated Catalogue of Japanese Shells, no. 7, p. 47 (genotype, *Metaxylophaga supplicata* Taki and Habe, monotypic).

Shell small, globose, teredo-like, beaked and widely gaping anteriorly throughout life, broadly rounded and closed posteriorly. Beaks truncated at nearly right angles to the anterior margin of the disc. Beaks and anterior portion of the disc sculptured with numerous, finely denticulated ridges. Umbonal-ventral sulcus present but variable and expressed internally as a pronounced ridge which usually terminates in a small ventral condyle. Umbonal reflection narrow and variable: it may or may not extend over the umbos. Apophyses absent. Chondrophore and internal ligament present. Dorsal plates consisting of a divided mesoplax which may cover the umbos or be placed anterior to them. Siphons variable: in some species the excurrent siphon is truncated at the posterior margin of the valves, in others it is nearly as long as the incurrent siphon.

Purchon (1941) removed the genus *Xylophaga* from the family Pholadidae and created for it a new family, the Xylophaginidae. However, so little is known concerning the soft anatomy of the many species of the Pholadidae, it seems unwise to make such a move at this time. Certainly, on the basis of shell characters, *Xylophaga* is more closely related to the Pholadidae than to the Teredinidae. The presence of the mesoplax, the lack of apophyses, and the agglutination of the fecal pellets to form a "chimney" are characters found in other pholad genera. Many species of pholads have a small chondrophore and internal ligament, and two genera, *Nettastomella* and *Jouannetia*, lack apophyses. Purchon states that *Xylophaga* is a wood borer while the pholads are rock borers. However, *Martesia*, one of the most abundant of the pholads, is also a wood borer. The alternation of sexes which is mentioned as showing an affinity with the Teredinidae has also been demonstrated for *Martesia* (Moore 1947). Though at least some species of *Xylophaga* retain their young, this is of no great importance for in the Teredinidae some groups, such as *Teredo*, do, while others, such as *Bankia*, do not. The reduction of the excurrent siphon is mentioned as one of the characteristics peculiar to the Xylophaginidae, but in *Xylophaga atlantica* Richards, the excurrent siphon is only very slightly shorter than the incurrent siphon and is in other respects normal. Consequently, we are including *Xylophaga* in the Pholadidae in the subfamily Xylophaginae.

Three recently described genera have been submerged under the genus *Xylophaga* in the synonymy given above. Fortunately it has been possible to study type specimens of the type species of all three.

The genus *Xylophaga* seems to be largely pelagic, occurring mainly in floating and waterlogged wood. The genus is world-wide in distribution, but does not occur in sufficient numbers to be of any real economic importance. One species, *X. abyssorum* Dall, has been recorded as boring into mud and soft stone, but this is open to question.

Genotype, *Teredo dorsalis* Turton, monotypic.

### *Xylophaga dorsalis* Turton

Plate 88

*Teredo dorsalis* Turton 1819, A Conchological Dictionary of the British Islands, p. 185 (Devonshire Coast, England).

*Xylophaga dorsalis* Turton 1822, Conchyliæ Insularum Britannicarum, p. 253; Verkrüzen 1872, Norwegen Seine Fjorde Und Naturwunder, p. 35; Purchon 1941, Journal Marine Biological Association United Kingdom 25, pp. 1-39.

*Pholas xilophaga* Deshayes 1835 [in] Lamarck, Animaux sans Vertèbres, ed. 2, 6, p. 47.

*Distinctive characters.* Beak extending less than half the distance to the ventral margin. Mesoplax large, divided, semicircular in outline and placed over the umbos. Posterior adductor muscle scar more or less circular in outline and nearly smooth. Umbonal-ventral sulcus shallow. Excurrent siphon truncated at the posterior margin of the valves.

*Description.* Shell globose, small, reaching about 10 mm. (about  $\frac{3}{8}$  inch) in length, white to light brown in color and fragile. Shell gaping anteriorly throughout life, closed posteriorly. Anterior slope beaked, the beak extending less than half the distance to the ventral margin and truncated at nearly a right angle, giving the shell a teredo-like appearance. Beak sculptured with numerous rows of finely denticulated ridges which run parallel to the ventral margin. Anterior portion of the disc sculptured with close-set denticulated ridges which parallel the anterior margin. The ridges of the disc are much more closely set than on the beak. Posterior to the denticulated portion of the disc there is a broad, shallow umbonal-ventral sulcus which is sculptured only with fine growth lines. Posterior slope inflated, with a high, ear-like lobe posteriorly and sculptured only with growth lines. Umbos prominent and located near the anterior fourth of the shell. Umbonal reflections narrow, only partially covering the umbos, appressed near the umbos and free anteriorly. Dorsal plates consisting of a relatively large, divided, semicircular mesoplax which covers the umbos. Interior of shell white and glazed. Muscle scars well marked. Posterior adductor muscle scar large, smooth and nearly circular. Anterior adductor muscle scar covering most of the umbonal reflection. Pallial sinus not apparent. Umbonal-ventral sulcus expressed internally as a pronounced ridge with a condyle at the ventral margin. Chondrophore present in left valve. Internal ligament present but small. Apophyses lacking.

Siphons small, the incurrent siphon extending about twice the length of the shell, and as much as 1 cm. beyond the surface of the wood. Aperture of the incurrent siphon sur-

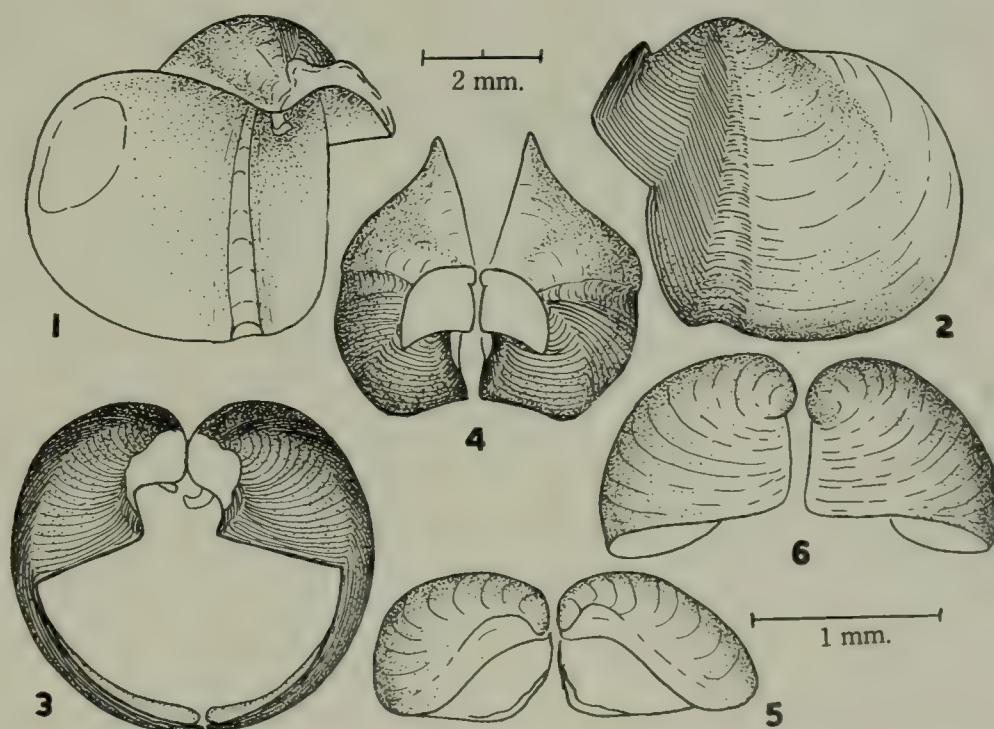


Plate 88. *Xylophaga dorsalis* Turton. Fig. 1. Internal view of valve to show the chondrophore, the pronounced umbonal-ventral ridge and the posterior adductor muscle scar. Fig. 2. External view of valve showing the shallow umbonal-ventral sulcus. Fig. 3. Anterior view (pedal gape) of apposed valves to show the chondrophore and the points of contact of the valves. Fig. 4. Dorsal view to show the mesoplax in place. Fig. 5. Ventral view of the mesoplax. Fig. 6. Dorsal view of the mesoplax. All from Millport, Ayr, Scotland.

rounded by six small cirri. Excurrent siphon truncated at about the posterior margin of the valves, and lacking cirri. A paired series of lappets, all that remains of the excurrent siphon, extend from the truncation of the excurrent siphon along the dorsal surface of the incurrent siphon. Fecal pellets are accumulated in the posterior portion of the burrow and these are fused together to form a "chimney" similar to that found in *Parapholas*.

length	height	ratio h:l	
6.5 mm.	5.5 mm.	1.2	Plymouth, England
5.0	5.0	1.0	"

*Types.* The types of *Xylophaga dorsalis* Turton are probably in the British Museum. The type locality is Devonshire Coast, England.

*Remarks.* A description of this European species is included here; first, because it is the type of the genus and secondly, because until 1942 our Western Atlantic species was confused with it. The two species, however, are quite distinct and can be easily separated by the shape and position of the mesoplax. In *X. dorsalis* Turton, this plate is large, conspicuous, composed of two ear-shaped parts and covers the umbos. In *X. atlantica* Richards the mesoplax is small, composed of two triangular parts and is located anterior to the umbos.

*Xylophaga dorsalis* is most closely related to *X. globosa* Sowerby from the west coast of South America. It differs from this species mainly in the shape of the mesoplax and in the more pronounced umbonal-ventral sulcus of *globosa*.

*Xylophaga dorsalis* is not a common species, but on occasion it may be abundant in restricted localities. It occurs mainly in floating or submerged waterlogged wood, but occasionally is found in water-front structures, buoy markers and submarine cables, causing a minor amount of damage. Like other members of this family, specimens of this species boring into coverings of cables, hard wood or other similar substrata are malformed and stenomorphic.

A fine paper by R. D. Purchon on the anatomy and biology of *Xylophaga dorsalis* appeared in 1941. In this paper, Purchon considers in detail the ciliary mechanism of the mantle cavity, the morphology of the digestive and reproductive systems, and general shell structure. He demonstrated sexual dimorphism in this species, described the vesicula seminalis for the storage of sperm, and suggested that self-fertilization would be of great survival value to a pelagic species which lives in isolated communities.

*Range.* From Lofoten Islands, Norway south to the western Mediterranean, the Canary and Madeira Islands.

*Specimens examined.* NORWAY: below Dröbak, Oslofjord (USNM). SCOTLAND: off Shetland Islands (USNM); Millport, Ayr (C. M. Yonge). ENGLAND: Plymouth (USNM). FRANCE: La Croisic, Loire-Inférieure (MCZ).

### *Xylophaga globosa* Sowerby

Plate 89

*Xylophaga globosa* Sowerby 1835, Proceedings Zoological Society London, p. 110 (Valparaiso, Chile, from piece of wood dredged at 100 fathoms); Sowerby 1849, Thesaurus Conchyliorum **2**, pt. 10, p. 503, pl. 108, figs. 101-102.

*Pholas gibbosa* d'Orbigny 1846, Voyage dans L'Amérique Méridionale **5**, pt. 3, p. 501.

*Xylotomea globosa* Sowerby, Dall 1909, Proceedings United States National Museum **37**, p. 277.

*Xilotoma globosa* Sowerby, Gigoux 1934, Revista Chilena de Historia Natural, Santiago, p. 285.

*Distinctive characters.* Beak extending at least half the distance to the ventral margin. Mesoplax large, divided and covering the umbos. Posterior adductor muscle scar elongate-oval in outline and with a shelf at its anterior margin. Umbonal-ventral sulcus well impressed. Excurrent siphon truncated, being about  $\frac{1}{3}$  the length of the incurrent siphon.

*Description.* Shell globose, small, reaching 8.5 mm. (about  $\frac{3}{8}$  inch) in length and 8 mm. (about  $\frac{3}{8}$  inch) in height, light brown to greenish-brown in color, gaping anteriorly throughout life and closed posteriorly. Anterior slope beaked, the beak extending at least half the distance to the ventral margin and truncated at nearly a right angle giving the shell a teredo-like appearance. Beak sculptured with numerous rows of finely denticulated ridges which parallel the ventral margin. Anterior portion of the disc also sculptured with close-set rows of denticulated ridges which parallel the anterior margin. Umbonal-ventral sulcus broad, moderately impressed and sculptured with concentric ridges and growth lines. Posterior slope tapering to a rounded posterior margin and sculptured with growth lines. Umbos prominent and located near the anterior third of the shell. Umbonal reflections narrow, only partially covering the umbos, appressed near the umbos and free anteriorly. Dorsal plate consisting of a large, divided mesoplax, each half being ear-shaped and sculptured with concentric growth lines. Interior of the shell white and glazed. Muscle scars well marked. Posterior adductor muscle scar large, smooth, elongate-oval in outline, and bounded on its anterior margin by a shelf. Anterior adductor muscle scar covering the umbonal reflection. A ventral adductor muscle scar is evident in some specimens. Pallial sinus usually not apparent. Umbonal-ventral sulcus expressed internally as a pronounced ridge with a condyle at its ventral margin. A small chondrophore is present in the left valve. Internal ligament present but small. Apophyses lacking.

Siphons extending about twice the length of the shell. Aperture of the incurrent siphon with numerous small cirri. Excurrent siphon truncated, being about one third the length of the incurrent siphon. A portion of the side walls of the excurrent siphon remains and this is fringed with a series of lappets which extend from the opening of the excurrent

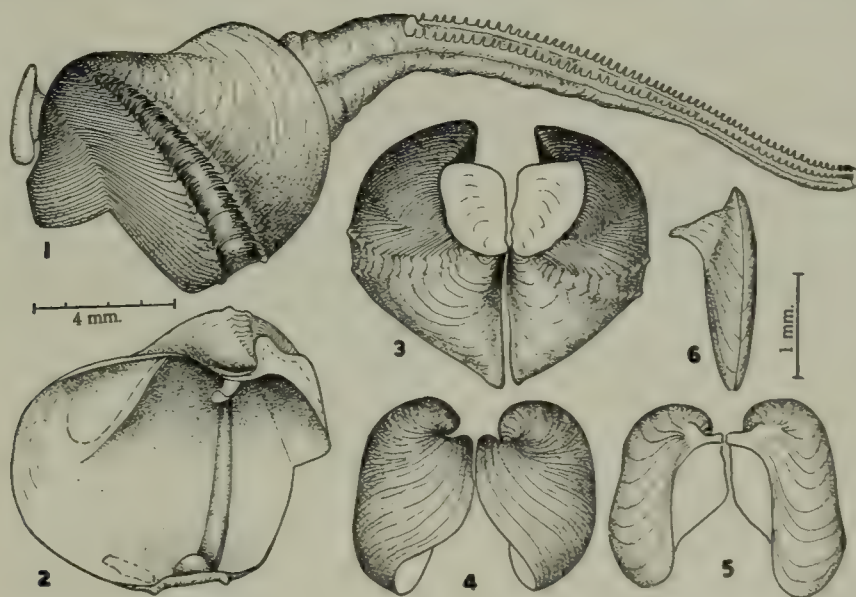


Plate 89. *Xylophaga globosa* Sowerby. Fig. 1. Side view of a complete specimen showing the position of the mesoplax, the pronounced umbonal-ventral sulcus and the truncate excurrent siphon, with only a row of lappets extending posteriorly on either side of the dorsal surface of the incurrent siphon. This condition is like that found in *X. dorsalis* Turton. Fig. 2. Internal view of valve showing the chondrophore, the position of the posterior adductor muscle scar, the shelf and the pronounced ventral condyle. Fig. 3. Dorsal view of shell showing the mesoplax in place. Fig. 4. Dorsal view of mesoplax. Fig. 5. Ventral view of mesoplax. Fig. 6. Side view of mesoplax. All from Piedra Azul, 7 miles east of Puerto Montt, Chile.

siphon along the dorsal surface of the incurrent siphon to its posterior extremity. Mantle and siphons light ivory in color and smooth. Foot large, diamond shaped and truncate. The above description of the soft parts is based on preserved material.

length	height	ratio h:l					
8.5 mm.	8 mm.	1.06	About 7 miles east of Puerto Montt,	Chile			
8.0	7	1.1	"	"	"	"	"

*Types.* The type of *Xylophaga globosa* Sowerby is in the British Museum; the type locality is Valparaiso, Chile in waterlogged wood dredged in 60 fathoms, Hugh Cuming collector.

*Remarks.* *Xylophaga globosa* is closely related to *X. dorsalis* Turton. It differs in the elongate-oval shape of the posterior adductor muscle scar, the less inflated posterior slope, the larger beak which often extends more than half the distance to the ventral margin, and the more pronounced umbonal-ventral sulcus. In addition, the shape of the mesoplax is quite different as shown in the figures for the two species. The excurrent siphon of *X. dorsalis* is truncated at the posterior margin of the valve while that of *globosa* extends to about one third the length of the incurrent siphon.

*Xylophaga globosa* Sowerby, while not common, is probably not an excessively rare species even though there are very few specimens in museum collections. The University of Lund Expedition to Chile collected this species at five stations near Puerto Montt, Chile and at two of these it was fairly abundant. The specimens were usually taken from submerged waterlogged wood dredged in 6 to 135 fathoms. One lot was obtained from a test board submerged in Puerto Montt Harbor in 3 meters. Apparently the species is not present in sufficient numbers to be of any great economic importance at this locality. In the samples examined the specimens had bored into the wood to a depth only slightly greater than the length of the shell, and usually across the grain.

*Range.* From Panama (Dall 1909) south to Chiloe Island, Chile.

*Specimens examined.* CHILE: Puerto Montt Harbor (S. Lat.  $41^{\circ}29'10''$ ; W. Long.  $72^{\circ}57'47''$ ) in  $1\frac{3}{4}$  fathoms; Tenglo Canal, Seno Reloncavi, near Puerto Montt (S. Lat.  $41^{\circ}29'33''$ ; W. Long.  $72^{\circ}58'38''$ ) in 6 fathoms; Bay of Puerto Montt between Isla Tenglo and Punta Pilluco (S. Lat.  $41^{\circ}30'05''$ ; W. Long.  $72^{\circ}56'22''$ ) in 135 fathoms; Piedra Azul, Seno Reloncavi, about 7 miles east of Puerto Montt (S. Lat.  $41^{\circ}31'30''$ ; W. Long.  $72^{\circ}48'15''$ ) in about 30 fathoms; Canal San Antonio, Golfo de Ancud (S. Lat.  $41^{\circ}44'10''$ ; W. Long.  $73^{\circ}15'15''$ ) in 8 fathoms. All Chiloe Province (all University of Lund Expedition to Chile).

### *Xylophaga mexicana* Dall

Plate 90

*Xylophaga mexicana* Dall 1908, Bulletin Museum of Comparative Zoölogy 43, no. 6, p. 425 (*Albatross*, station 3422, off Acapulco, Mexico in 141 fathoms).

*Distinctive characters.* Beak extending two thirds the distance to the ventral margin. Umbonal reflection narrow, slightly recurved and partially covering the umbo. Umbonal-ventral sulcus narrow, deep and with a small ridge at the posterior margin. Posterior adductor muscle scar large, oval, smooth and only lightly impressed.

**Description.** Shell globose, small, reaching 5 mm. (about  $\frac{1}{4}$  inch) in length and 4.2 mm. (about  $\frac{1}{8}$  inch) in height. Beaked and widely gaping anteriorly throughout life, rounded and closed posteriorly. Beak large, extending about two thirds the distance to the ventral margin. Beak sculptured with numerous rows of finely denticulated ridges which are parallel to the ventral margin. Anterior portion of the disc sculptured with crowded rows of finely denticulated ridges which are somewhat coarser than those of the beak. Umbonal-ventral sulcus rather narrow and deep, with a definite ridge at the posterior margin. Posterior slope inflated and broadly rounded, sculptured only by growth lines. Umbos prominent and located near the anterior third of the shell. Umbonal reflection narrow, free and only slightly recurved anteriorly. Posteriorly it is appressed but covers only the anterior half of the umbos. Dorsal plates unknown. Interior of the shell white and glazed. Muscle scars barely visible on the limited material available for study. Posterior adductor muscle scar large, oval in outline, smooth and only lightly impressed. It is located high on the posterior slope. Anterior adductor muscle scar covering most of the umbonal reflection. Umbonal-ventral sulcus expressed internally as a narrow, high, transversely grooved ridge, the grooves giving the ridge a segmented appearance. Chondrophore small. Apophyses lacking.

length	height	ratio h:l	
5 mm.	4.2 mm.	1.2	Holotype

**Types.** The holotype of *Xylophaga mexicana* Dall is in the United States National Museum, no. 122947, from the *Albatross*, station 3422, off Acapulco, Mexico (N. Lat.  $16^{\circ}47'$ ; W. Long.  $99^{\circ}59'$ ) in 141 fathoms.

**Remarks.** Though this species is based on a single, poor, dead specimen, it appears to be quite distinctive. Lacking the dorsal plate, it is impossible to say definitely where this species belongs. However, the size of the beaks, the nearly smooth muscle scars, the broadly reflected dorsal margin and the deep, narrow umbonal-ventral sulcus with a pronounced ridge at its posterior margin relate it most closely to *X. globosa* Sowerby. In fact it may prove to be this species.

**Range.** Known only from the type locality.

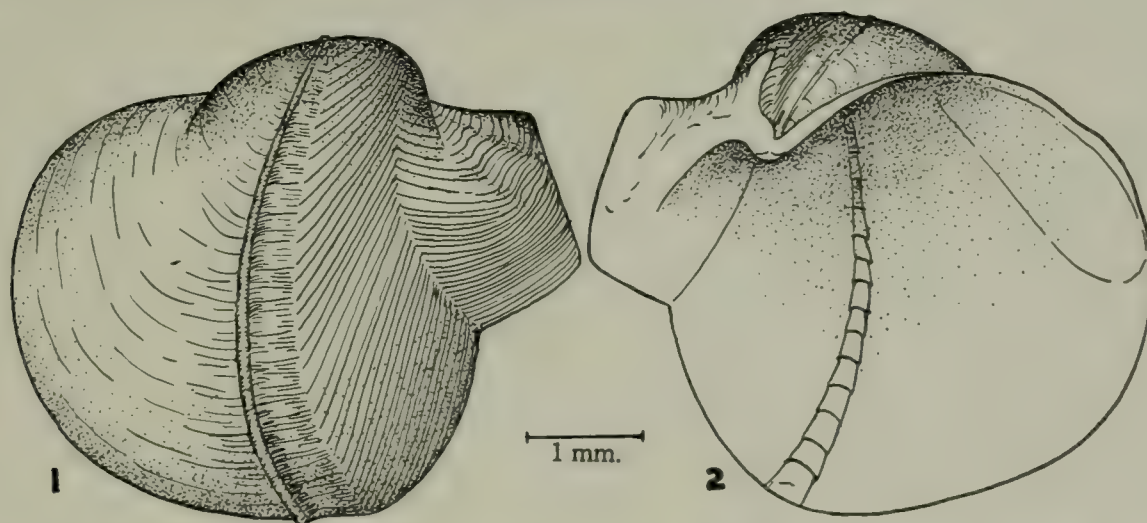


Plate 90. *Xylophaga mexicana* Dall. Fig. 1. External view of the valve of the holotype showing the pronounced ridge on the posterior margin of the umbonal-ventral sulcus, and the beak which extends more than half the distance to the ventral margin. Fig. 2. Internal view of the valve of the holotype showing the umbonal-ventral ridge and the muscle scar. From off Acapulco, Mexico.

*Specimens examined.* MEXICO: *Albatross*, station 3422, off Acapulco, Mexico (N. Lat.  $16^{\circ}47'$ ; W. Long.  $99^{\circ}59'$ ) in 141 fathoms.

### *Xylophaga atlantica* Richards

Plates 4 and 91

*Xylophaga atlantica* Richards 1942, *Nautilus* **56**, p. 68, pl. 6, fig. 4 (east coast of the United States).

*Distinctive characters.* Beak extending less than half the distance to the ventral margin. Mesoplax triangular, divided and located anterior to the umbos. Umbonal-ventral sulcus shallow with a median thread-like groove. Posterior adductor muscle scar elongate-oval and irregularly marked. Excurrent siphon nearly as long as the incurrent siphon.

*Description.* Shell globose, small, reaching 14.5 mm. (about  $\frac{1}{2}$  inch) in length and 15 mm. (about  $\frac{1}{2}$  inch) in height, white to light brown in color and fragile. Gaping anteriorly throughout life and closed posteriorly. Anterior slope beaked, the beak extending less than half the distance to the ventral margin and truncated at nearly a right angle, giving the shell a teredo-like appearance. Beak sculptured with numerous rows of denticulated ridges which parallel the ventral margin of the beak. Anterior portion of the disc sculptured with denticulated ridges paralleling the anterior margin. The ridges of the disc are more closely spaced and coarsely denticulated than those of the beak. Umbonal-ventral sulcus shallow, with a median thread-like groove. Posterior slope inflated and having a high, ear-like lobe posteriorly. It is smooth and sculptured only with faint growth lines. Umbos prominent and located near the anterior third of the shell. Dorsal margin of the valves reflected anterior to the umbos only. Reflection narrow and free. Mesoplax minute, divided and located anterior to the umbos. The two parts are triangular in outline and have a small cavity below into which the posterior portion of the anterior adductor muscle extends. Mesoplax of young similar to that of the adult. Interior of shell white and glazed. Muscle scars well marked. Posterior adductor muscle scar large, oval in outline, located high on the posterior slope and irregularly marked. Anterior adductor muscle scar covering most of the reflection of the valves. Pallial sinus not apparent. Umbonal-ventral sulcus expressed internally as a pronounced ridge with a condyle at its ventral margin. A rather large chondrophore is present in the left valve. Internal ligament clearly visible. Apophyses lacking. Siphons white to light ivory in color, smooth, devoid of periostracum and probably not extending more than the length of the shell. Siphons united, the excurrent siphon being about three fourths the length of the incurrent siphon. Opening of the excurrent siphon surrounded by 6 to 8 large papillae. Aperture of incurrent siphon with numerous small papillae. Foot and mantle white. Foot nearly circular in outline and truncate.

length	height	ratio h:l	
14.5 mm.	15.0 mm.	.96	off Cape Breton, Nova Scotia
11.0	10.5	1.04	Holotype
9.5	9.5	1.00	off Block Island, Rhode Island
8.0	7.5	1.06	Mount Desert Island, Maine
8.0	8.5	.94	Perry, Maine

*Types.* The holotype of *Xylophaga atlantica* Richards is in the Academy of Natural Sciences Philadelphia, no. 178741. The locality as given by Richards was the east coast

of the United States. The type locality is here restricted to Mount Desert Island, Maine, a locality from which specimens are known to have been taken from fixed structures.

*Remarks.* It is surprising that this Western Atlantic species remained undescribed until 1942. All early references to *Xylophaga dorsalis* Turton along our Atlantic coast are actually to this species, as *X. dorsalis* of Europe is not found in our waters. The shells of the two species are superficially similar but *X. atlantica* is a much larger species with a small mesoplax which is located anterior to, rather than over, the umbos. The posterior adductor scar of *X. atlantica* is elongate-oval in outline and is marked with irregular grooves, while that of *X. dorsalis* is more or less circular in outline and nearly smooth. In addition, the excurrent siphon of *X. atlantica* is nearly as long as the incurrent siphon while in *X. dorsalis* it is truncated at the posterior margin of the valve.

*Xylophaga atlantica* Richards is most closely related to *X. washingtona* Bartsch of the Eastern Pacific but may be separated from that species by its irregularly marked posterior adductor muscle scar and its broadly triangular mesoplax which has a very small ventral portion. See also remarks under *X. washingtona* Bartsch.

Very little is known concerning the biology of this species. Like others in the genus *Xylophaga* it appears to be essentially pelagic. It is seldom taken in fixed structures, most specimens coming from floating or waterlogged wood. It ranges from off Quebec south to Virginia and has been taken alive from waterlogged wood brought up from depths of 50 fathoms. There are numerous records of specimens taken from wood dredged in 100 to over 1000 fathoms but no mention was made as to whether the specimens were living or dead. Under *Specimens examined* the fathoms for each of the U. S. Fisheries stations is given but this does not necessarily indicate that the specimens were taken alive at such depths.

The young of *Xylophaga atlantica* Richards are held within the brood pouch until the

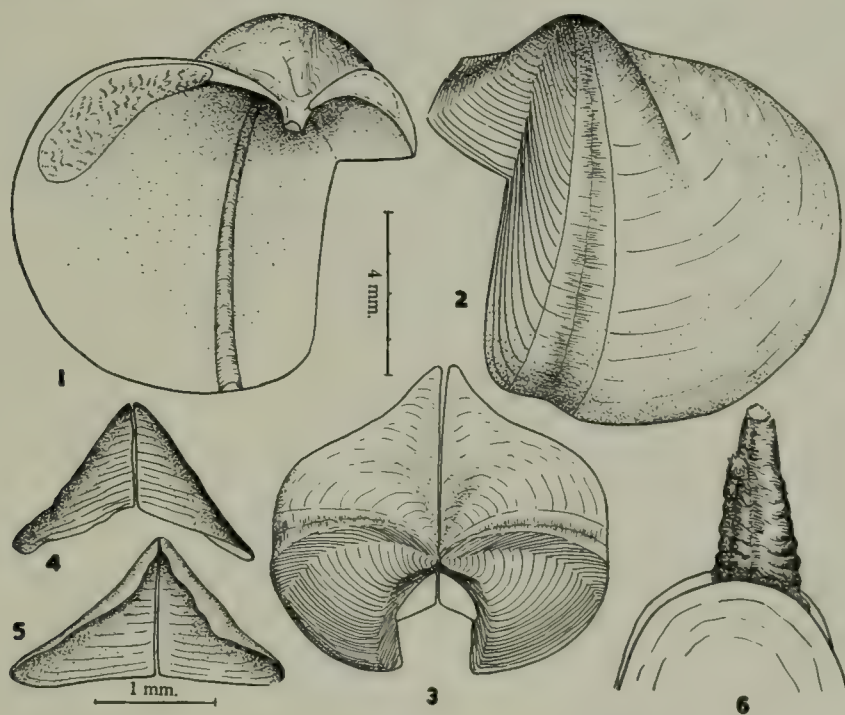


Plate 91. *Xylophaga atlantica* Richards. Fig. 1. Internal view of left valve showing the irregularly sculptured posterior adductor muscle scar. From off Cape Breton Island, Nova Scotia. Fig. 2. External view of the left valve of the holotype showing the shallow umbonal-ventral sulcus with the thread-like median groove. Fig. 3. Dorsal view of shell showing the mesoplax in place. Fig. 4. Dorsal view of mesoplax. Fig. 5. Ventral view of mesoplax. Fig. 6. Siphons of a preserved specimen showing that the excurrent siphon is nearly as long as the incurrent siphon. All from Perry, Maine.

late veliger stage. The embryonic shell is about  $\frac{1}{2}$  mm. in length with pronounced concentric sculpture, simple, straight hinge line and prominent umbos. Metamorphosis of the shell into the adult form begins even before the young are released. The embryonic shell is figured on plate 4.

*Range.* From St. Lawrence estuary, Quebec, Canada south to Cape Henry, Virginia.

*Specimens examined.* CANADA: Trois Pistoles, St. Lawrence Estuary, Quebec (USNM); St. Pierre Bank, about 180 miles east of Cape Breton Island; about 270 miles southeast of Cape Breton Island, in a trawl marker buoy (both J. Miller). MAINE: Perry; Mount Desert Island (both MCZ); off North Haven in 10 fathoms (USNM). MASSACHUSETTS: Rockport (MCZ); Annisquam River, Gloucester (J. Miller); 10 miles east of Boston Lightship (MCZ); Brown's Bank, about 260 miles east of Boston (USNM); off Cohasset (J. Miller); Provincetown (MCZ); *Speedwell*, station 194, 180 miles east of Gloucester (N. Lat.  $42^{\circ}33'$ ; W. Long.  $69^{\circ}58'$ ) in 110 fathoms; *Speedwell*, station 198, about 120 miles east of Manchester (N. Lat.  $42^{\circ}30'$ ; W. Long.  $70^{\circ}20'$ ) in 50 fathoms; *Speedwell*, station 234, about 60 miles east of Salem (N. Lat.  $42^{\circ}30'$ ; W. Long.  $70^{\circ}38'$ ) (all USNM); Georges Bank, 155 miles east of Cape Cod (N. Lat.  $41^{\circ}20'$ ; W. Long.  $66^{\circ}50'$ ) (MCZ); *Albatross*, station 2076, off Georges Bank, 180 miles east of Cape Cod (N. Lat.  $41^{\circ}13'$ ; W. Long.  $66^{\circ}00'$ ), in 906 fathoms (USNM); Georges Bank, 65 miles east of Cape Cod (N. Lat.  $41^{\circ}18'$ ; W. Long.  $68^{\circ}40'$ ) in 50 fathoms (MCZ). RHODE ISLAND: off Block Island (J. Miller). NEW JERSEY: *Fish Hawk*, station 1162, about 190 miles east of Sandy Hook (N. Lat.  $40^{\circ}32'$ ; W. Long.  $70^{\circ}39'$ ) in 45 fathoms; *Albatross*, station 2550, 160 miles east of Barnegat Bay (N. Lat.  $39^{\circ}44'$ ; W. Long.  $70^{\circ}30'$ ); *Fish Hawk*, station 998, 120 miles east of Barnegat Bay (N. Lat.  $39^{\circ}43'$ ; W. Long.  $71^{\circ}32'$ ) in 302 fathoms; *Fish Hawk*, station 1140, 105 miles east of Atlantic City (N. Lat.  $39^{\circ}34'$ ; W. Long.  $71^{\circ}56'$ ) in 374 fathoms; *Albatross*, station 2041, 285 miles due east of Atlantic City (N. Lat.  $39^{\circ}22'$ ; W. Long.  $68^{\circ}25'$ ) in 1608 fathoms; *Albatross*, station 2036, about 270 miles east of Cape May (N. Lat.  $38^{\circ}52'$ ; W. Long.  $69^{\circ}24'$ ) in 1735 fathoms (all USNM). VIRGINIA: *Albatross*, station 2736, Hampton Roads in 11 fathoms; *Albatross*, station 2566, 405 miles east of Cape Charles (N. Lat.  $37^{\circ}23'$ ; W. Long.  $68^{\circ}08'$ ) on surface; *Albatross*, station 2731, about 75 miles east southeast of Cape Henry (N. Lat.  $36^{\circ}45'$ ; W. Long.  $74^{\circ}28'$ ) in 781 fathoms; *Albatross*, station 2012, 65 miles east southeast of Cape Henry (N. Lat.  $36^{\circ}41'$ ; W. Long.  $74^{\circ}39'$ ) in 66 fathoms; *Albatross*, station 2729, 75 miles east southeast of Cape Henry (N. Lat.  $36^{\circ}36'$ ; W. Long.  $74^{\circ}32'$ ) in 679 fathoms (all USNM).

### *Xylophaga washingtona* Bartsch

#### Plate 92

*Xylophaga washingtona* Bartsch 1921, Proceedings Biological Society Washington 34, p. 32 (San Juan Island, Washington).

*Xylophaga californica* Bartsch 1921, Proceedings Biological Society Washington 34, p. 32 (off Pt. Pinos Light, California).

*Distinctive characters.* Beak extending less than half the distance to the ventral margin. Umbonal-ventral sulcus broad and shallow. Mesoplax triangular in outline, divided and located anterior to the umbos. Posterior adductor muscle scar elongate-oval in outline and regularly marked with a central and radiating grooves.

**Description.** Shell globose, small, reaching 6 mm. (about  $\frac{1}{4}$  inch) in length and 6.3 mm. (about  $\frac{1}{4}$  inch) in height. Widely gaping anteriorly throughout life and closed posteriorly. Anterior slope beaked, the beak extending less than half the distance to the ventral margin and truncated at nearly a right angle giving the shell a teredo-like appearance. Beak sculptured with numerous rows of finely denticulated ridges, the rows running parallel to the ventral margin. Anterior portion of the disc sculptured with finely denticulated ridges which parallel the anterior margin. The ridges of the disc are more closely spaced and more coarsely denticulate than those of the beak. Umbonal-ventral sulcus wide and shallow, and sculptured only by faint growth lines. Posterior slope inflated, rounded posteriorly, with a high ear-like lobe, and sculptured only by growth lines. Umbos prominent and located near the anterior third of the shell. Dorsal margin of the valves reflected anterior to the umbos only. Reflection narrow and free. Dorsal plate consisting of a minute, divided, triangular mesoplax which is located anterior to the umbos and partially encloses the anterior adductor muscle. Interior of the shell white and glazed. Muscle scars well marked. Posterior adductor muscle scar large, oval in outline and located high on the posterior slope. The scar is rough, but regularly marked with a central groove and numerous radiating grooves. Anterior adductor muscle scar covering the umbonal reflection. Pallial sinus not apparent. Umbonal-ventral sulcus expressed internally as a narrow and high ridge with a condyle at its ventral margin. A rather large chondrophore is located on the left valve. Internal ligament present. Apophyses lacking.

length	height	ratio h:l	
6.0 mm.	6.3 mm.	0.95	Station 2867, off coast of Washington
5.9	6.0	0.98	" " " " " "
5.8	5.2	1.1	Holotype, <i>Xylophaga washingtona</i> Bartsch
4.8	4.8	1.0	Holotype, <i>Xylophaga californica</i> Bartsch

**Types.** The holotype of *Xylophaga washingtona* Bartsch from San Juan Island, Washington is in the United States National Museum, no. 334479, as is that of *X. californica* Bartsch, no. 209876, from *Albatross*, station 4523, off Point Pinos Light, California.

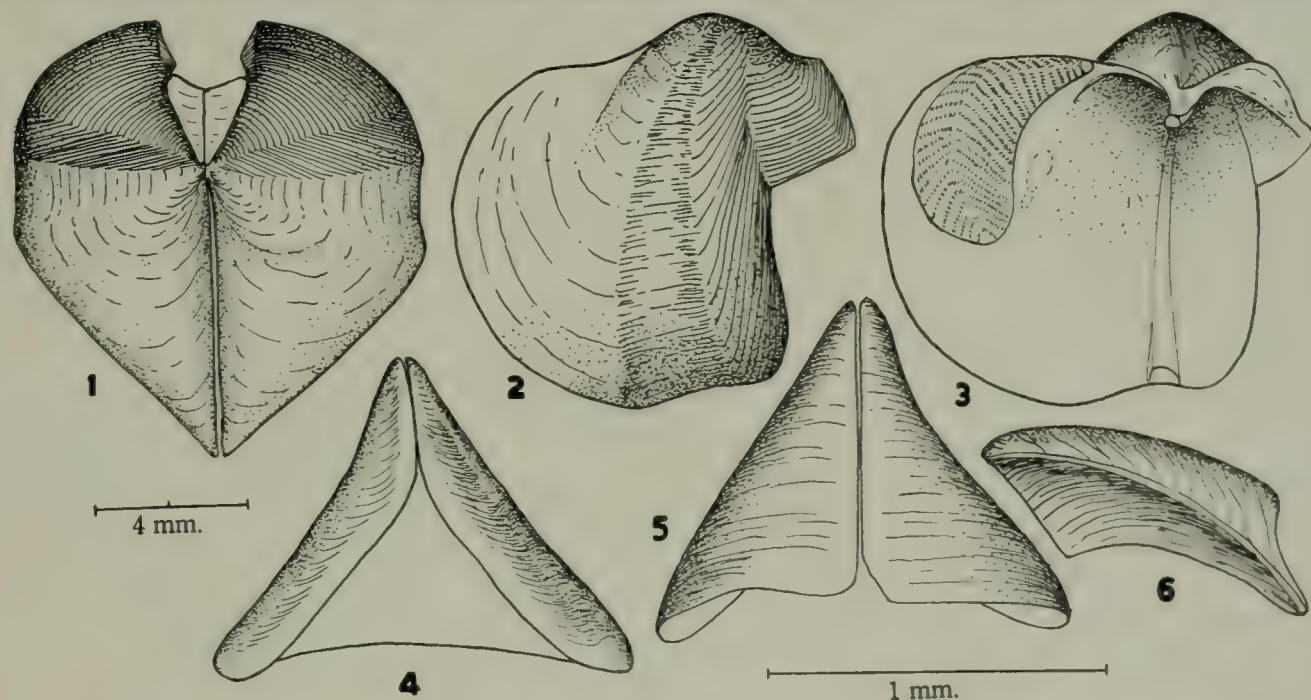


Plate 92. *Xylophaga washingtona* Bartsch. Fig. 1. Dorsal view of paratype showing the mesoplax in place. Fig. 2. External view of right valve of the holotype showing the shallow, smooth umbonal-ventral sulcus. Fig. 3. Internal view of left valve of the holotype showing the regularly marked posterior adductor muscle scar. Fig. 4. Ventral view of mesoplax. Fig. 5. Dorsal view of mesoplax. Fig. 6. Side view of mesoplax. All specimens from San Juan Island, Washington.

*Remarks.* *Xylophaga washingtona* Bartsch appears to be most closely related to *Xylophaga atlantica* Richards of the Western Atlantic. It is, however, a smaller species, the mesoplax is longer in proportion to its width, with a larger ventral portion, and the posterior adductor muscle scar is regularly marked. In addition, the umbonal-ventral sulcus of *X. atlantica* Richards has a distinct, thread-like median groove which corresponds to the internal ridge. From *Xylophaga mexicana* Dall this species differs by having the beak extending less than half the distance to the ventral margin and by having a shallow, broad umbonal-ventral sulcus, not bounded by a distinct posterior ridge. In addition, the posterior adductor muscle scar is large and distinctly marked.

The type specimens of *Xylophaga californica* Bartsch are small, poor specimens of *X. washingtona* Bartsch. Both species were described in the same paper and though *X. californica* was the first described, the specimens were so poor and fragmentary that it seemed best to place it in the synonymy of *X. washingtona* of which Bartsch had good and ample material.

*Specimens examined.* WASHINGTON: Friday Harbor, San Juan Islands (MCZ); *Albatross*, station 3456, Straits of Juan de Fuca (N. Lat.  $48^{\circ}31'$ ; W. Long.  $124^{\circ}43'$ ) in 136 fathoms (USNM); Ballard Bay in 10 fathoms (W. J. Eyerdam); Departure Bay; *Albatross*, station 2867, off Flattery Rocks (N. Lat.  $48^{\circ}07'$ ; W. Long.  $124^{\circ}55'$ ) in 37 fathoms (both USNM). OREGON: *Albatross*, station 5432, about 20 miles off Cape Meares Lightship in 97 fathoms (USNM). CALIFORNIA: *Albatross*, station 4523, off Point Pinos Light in 75–108 fathoms (USNM).

### *Xylophaga abyssorum* Dall

#### Plate 93

*Xylophaga abyssorum* Dall 1886, Bulletin Museum Comparative Zoölogy **12**, p. 317, pl. 9, figs. 7, 7a (*Blake*, station 215, N. Lat.  $13^{\circ}51'$ ; W. Long.  $61^{\circ}03'$ , off St. Lucia in 226 fathoms).

*Distinctive characters.* Beak extending less than half the distance to the ventral margin. Umbonal-ventral sulcus shallow and bounded on its posterior margin by a pronounced keel. Posterior adductor muscle scar broadly oval and irregularly roughened.

*Description.* Shell minute, globose, reaching 4 mm. (about  $\frac{1}{6}$  inch) in length and 3.5 mm. (about  $\frac{1}{8}$  inch) in height, white in color and fragile. Beaked and widely gaping anteriorly throughout life, rounded and closed posteriorly. Beak extending less than half the distance to the ventral margin and truncated nearly at a right angle to the anterior margin of the disc, giving the shell a teredo-like appearance. Beak sculptured with numerous rows of finely denticulated ridges, the rows running parallel to the ventral margin of the beaks. Anterior portion of the disc sculptured with crowded rows of denticulated ridges which run parallel to the anterior margin of the disc. The ridges of the disc are more closely crowded and more coarsely denticulated than those of the beaks. Remainder of the disc composed of a broad, rather shallow umbonal-ventral sulcus which is sculptured only by growth lines. Ridge bounding the anterior edge of the sulcus, low and rounded, the one on the posterior edge high and sharp. Posterior slope inflated, rounded and sculptured with concentric growth lines and low ridges. Umbo prominent, located near the anterior third of the shell. Dorsal margin of the valves reflected anterior to the umbos only. Accessory plates unknown. Interior of shell white and glazed. Muscle scars

well marked. Posterior adductor muscle scar large, broadly oval in outline and roughened. Anterior adductor muscle scar covering a small portion of the dorsal reflection. Pallial sinus not apparent. Umbonal-ventral sulcus expressed internally as a low, beaded ridge with a large condyle at the ventral margin. A small chondrophore is present in the left valve. Apophyses lacking.

length	height	ratio h:l	
4.8 mm.	4.5 mm.	1.0	off Atlantic City, New Jersey
4.0	3.5	1.1	Holotype
2.0	2.0	1.0	off Cape Hatteras, North Carolina

*Types.* The holotype of *Xylophaga abyssorum* Dall is in the Museum of Comparative Zoölogy, no. 8135. The type locality is *Blake*, station 215 (N. Lat.  $13^{\circ}51'$ ; W. Long.  $61^{\circ}03'$ ), off St. Lucia, Lesser Antilles in 226 fathoms.

*Remarks.* This rare species is easily distinguished from others in the genus by its minute size and by the strong keel which separates the disc from the posterior slope. Dall in his original description stated that he had not seen any accessory plates nor an attachment area for them. However, a single specimen from off Cape Hatteras, North Carolina had a fragment of a plate remaining but this was too incomplete to attempt a description.

It would appear from the record that this species may bore into mud, sand and soft stone. This habit is quite contrary to that of all other *Xylophaga*. However, all specimens studied were dredged from considerable depths and all appeared to have been dead at the time they were taken. Consequently, little can be said as to their true habitat.

*Range.* From off Atlantic City, New Jersey south through the Lesser Antilles to St. Lucia.

*Specimens examined.* NEW JERSEY: *Albatross*, station 2095 (N. Lat.  $39^{\circ}29'$ ; W. Long.  $70^{\circ}58'$ ) about 200 miles off Atlantic City in 1342 fathoms in globigerine ooze (USNM). NORTH CAROLINA: *Albatross*, station 2115 (N. Lat.  $35^{\circ}49'$ ; W. Long.  $74^{\circ}34'$ ) about 40 miles off Cape Hatteras in 843 fathoms in mud and fine sand (USNM). FLORIDA: *Albatross*, station 2668 (N. Lat.  $30^{\circ}58'$ ; W. Long.  $79^{\circ}38'$ ) about 68 miles off Fernandina in 294 fathoms (USNM). LESSER ANTILLES: *Blake*, station 192 (N. Lat.  $15^{\circ}17'$ ; W. Long.  $61^{\circ}24'$ ) off Dominica in 138 fathoms (USNM); *Blake*, station 215 (N. Lat.  $13^{\circ}51'$ ; W. Long.  $61^{\circ}03'$ ) off St. Lucia in 226 fathoms in a coral nodule (MCZ).

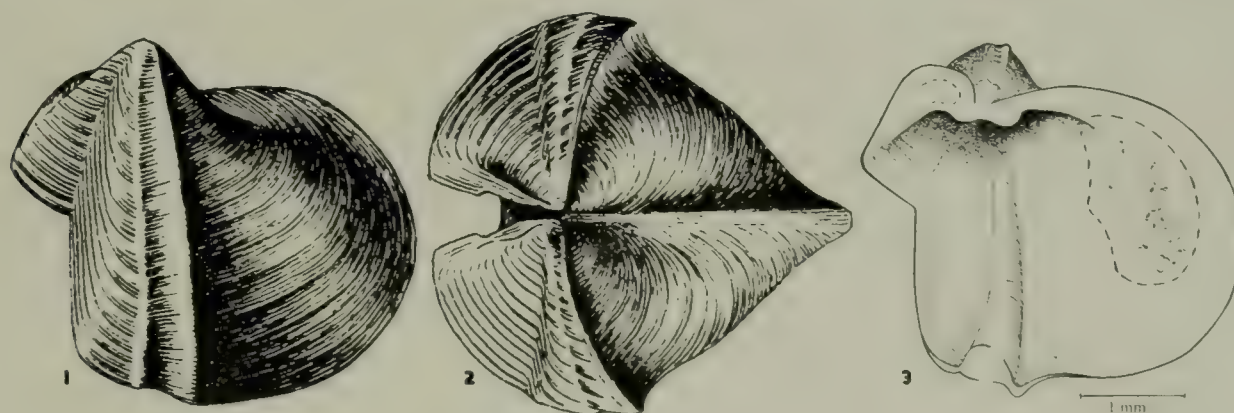


Plate 93. *Xylophaga abyssorum* Dall. Fig. 1. External view of the left valve of the holotype. Fig. 2. Dorsal view of the holotype showing the pronounced ridge on the posterior margin of the umbonal-ventral sulcus (Fig. 1 and 2 after Dall 1886). Fig. 3. Internal view of the right valve of the holotype to show the large umbonal-ventral ridge and the muscle scars.

## Key for the identification of the genera of the Pholadidae

(based upon complete adult specimens)

1. Adult shell with a callum . . . . . 7  
    Adult shell without a callum . . . . . 2
2. Shell with apophyses . . . . . 3  
    Shell without apophyses . . . . . *Xylophaga*
3. Shell with more than one dorsal plate . . . . . 6  
    Shell with only one dorsal plate . . . . . 4
4. Shell with protoplax only . . . . . *Barnea*  
    Shell with mesoplax only . . . . . 5
5. Shell beaked anteriorly, mesoplax in one piece, umbonal-ventral sulcus present . . . . . *Zirfaea*  
    Shell rounded anteriorly, mesoplax in two pieces, umbonal-ventral sulcus not present . . . . . *Talona*<sup>1</sup>
6. Shell with a largely chitinous protoplax, a mesoplax but no metaplax, umbonal reflection not septate . . . . . *Cyrtopleura*  
    Shell with a calcareous protoplax, mesoplax and metaplax, umbonal reflection septate . . . . . *Pholas*
7. Shell with apophyses . . . . . 8  
    Shell without apophyses . . . . . 14
8. Animal capable of complete retraction within the shell . . . . . 9  
    Animal not capable of complete retraction within the shell . . . . . *Chaceia*
9. Dorsal plate one, a mesoplax . . . . . 10  
    Dorsal plates two, a mesoplax and a metaplax . . . . . 12
10. Mesoplax divided longitudinally . . . . . 11  
    Mesoplax not divided longitudinally . . . . . *Penitella*
11. Siphonoplax present, callum extended dorsally between the beaks. Rock borers . . . . . *Pholadidea*  
    Siphonoplax lacking, callum not extending dorsally beyond the beaks. Wood borers . . . . . *Lignopholas*
12. Valves divided into three distinct areas, posterior area with overlapping chitinous plates. Shell usually one or more inches in length *Parapholas*  
    Valves divided into two areas, posterior area without chitinous plates  
    Shell usually under one inch in length . . . . . 13
13. Shell with funnel-shaped pit below the umbonal reflection, callum not extending between the beaks. Wood borers . . . . . *Martesia*  
    Shell with the umbonal reflection closely appressed. Callum extending between the beaks and on either side of the mesoplax. Shell and rock borers . . . . . *Diplothyra*
14. Shell with complete and overlapping callum. Siphonoplax developed on right valve only . . . . . *Jouannetia*  
    Shell with incomplete callum. Siphonoplax developed on both valves equally . . . . . *Nettastomella*

<sup>1</sup> An African genus, not included in this report.

## Notes

Genus *Penitella* Valenciennes

Unfortunately the genus *Navea* Gray was omitted from the synonymy of *Penitella* which was considered on page 70. The name was based upon the young stage of a *Penitella*.

*Navea* Gray 1851, Annals and Magazine of Natural History (2) 8, p. 335 (genotype, *N. subglobosa* Gray, subsequent designation Stoliczka 1870).

### ***Barnea maritima* Dall**

*Barnea maritima* 'd'Orbigny' Dall 1889, Bulletin United States National Museum, no. 37, p. 72 (Texas) [nomen nudum].

It has been impossible to find any record of this name in d'Orbigny's writings. It may possibly have been a manuscript name on a specimen in the collection of the United States National Museum at the time Dall was compiling his list of the marine mollusks of the Southeastern Coast of the United States. Following Dall, C.W. Johnson included the name in his "Marine Mollusca of the Atlantic Coast from Labrador to Texas" and since then it has been mentioned in several other lists dealing with the Texas area though no one has ever described or figured it.

### ***Pholadidea tridens* Gray**

*Talona tridens* Gray 1843 in Dieffenbach's Travels in New Zealand 2, p. 254 (New Zealand).

*Pholas tridens* Gray, Sowerby 1849, Thesaurus Conchyliorum 2, p. 10, p. 398, pl. 106, figs. 60-61.

*Pholadidea tridens* Gray, Dall 1909, Proceedings United States National Museum 37, no. 1704, p. 277.

This species has been recorded by Sowerby, as coming from Montecristi, Ecuador, Hugh Cuming collector, and Dall (1909) lists it in his catalogue of Peruvian mollusks. However, we have not seen a specimen from the Eastern Pacific. Dall states (op. cit., p. 188) that he has included species "... belonging to a widely distributed group, such as the Pholadidae, though not actually reported from a Peruvian locality . . . knowing that in all probability it will be found on more thorough search in Peruvian territory." Dall's inclusion of *P. tridens* Gray was undoubtedly based on Sowerby's record which was based on Cuming material, a collection known to contain many errors of locality.<sup>1</sup> Consequently it seems best to omit this species from the Eastern Pacific fauna until material with known locality is obtained.

### ***Scyphomya semicostata* Lea**

*Pholas semicostata* H. C. Lea 1844, Proc. Boston Society Natural History 1, p. 204 (South Carolina): Lea 1845, Boston Journal Natural History 5, p. 285, pl. 24, fig. 1.

*Zirfaea semicostata* Lea, Dall 1889, Bulletin United States National Museum, no. 37, p. 72.

*Scyphomya semicostata* Lea, Dall 1898, Transactions Wagner Free Institute of Science, Philadelphia 3, pt. 4, p. 822.

This species was described from a single, minute specimen in poor condition and without definite locality. Even the locality, South Carolina, is open to question as Lea (1845) states "... this curious little species I found among some shells sent to my father many years since, from South Carolina." The species has been shifted from one genus to another and in 1898 Dall created the genus *Scyphomya* for its reception. At the time Dall created the genus he had not seen Lea's specimen, in fact, the location of the type is unknown. Specimens in the United States National Museum labeled by Dall as *semicostata* Lea proved to be *Jouannetia quillingeri* Turner. However, it is not certain that these were the specimens on which Dall based his generic name. Species in the genus *Jouannetia* lack apophyses but *semicostata* Lea, the type of *Scyphomya*, has them. Dall mentions the apophyses in the original description of his genus but states that they were missing in his specimens. Until more data are at hand it is impossible to place properly this genus and species.

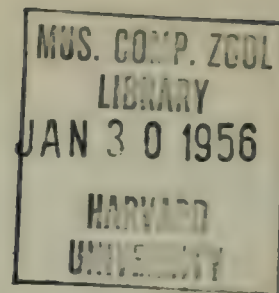
<sup>1</sup> Clench 1945, Occasional Papers On Mollusks 1, p. 26.

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MELONGENIDAE

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## THE FAMILY MELONGENIDAE IN THE WESTERN ATLANTIC

BY

WILLIAM J. CLENCH AND RUTH D. TURNER

The family Melongenidae possesses only a few species, but these occur in nearly all tropical and temperate seas. All are intertidal or live a little below low water and, so far as is known, are generally predatory in habit though occasionally feeding on dead animal matter. In certain areas, such as western Florida, they may be sufficiently abundant on oyster bars to be a rather serious menace.

*Melongena* has presented many challenging problems. This is particularly true of the polytypic species complex of *Melongena corona* Gmelin. Populations of this species only short distances apart may be strikingly different. Certain populations are very uniform while others show an amazing amount of variation (Plate 100). This type of variation suggests that some factor in their life cycle prevents wide dispersal of the young, and that the progeny of a colony remains within a limited area. Marine species having young which are readily dispersed are usually either quite uniform throughout their range or

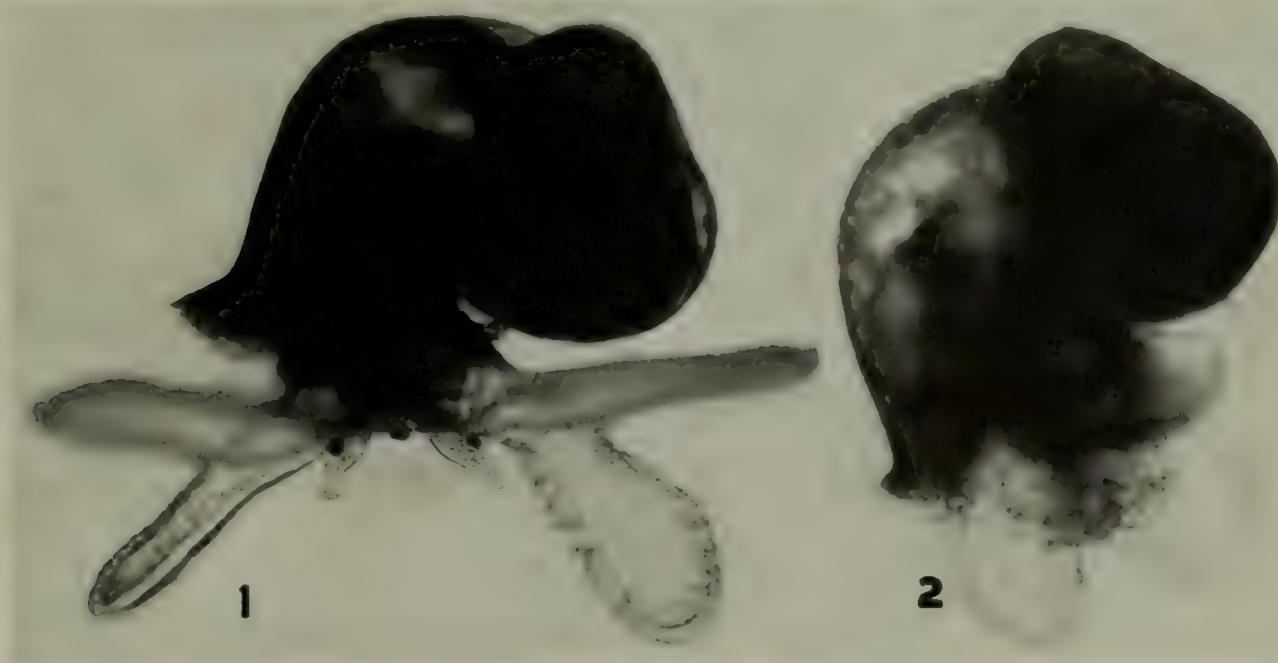


Plate 94. Veliger larvae of *Melongena corona* Gmelin, from Punta Rassa, Florida. Fig. 1. Late veliger stage (27 days old) just before emerging from the capsule, showing the four velar lobes, the tentacles, the eyes and the shell. Fig. 2. A specimen at the same stage with the animal partially retracted within the shell. The well-developed foot can be seen in the center with the velar lobes behind. The shell at this stage has one and one half whorls. (about 75x)

else show a gradient of change or a cline from one end of the range to the other. In order to determine the controlling factor, we kept specimens in an aquarium through the breeding season and found that all of the larval stages are passed within the egg capsule, the emerging young crawling snails being capable of only limited dispersal. Such young snails certainly could reach other colonies by mechanical means and this no doubt occasionally happens. However, mechanical transport on floating mangrove leaves or other debris appears to be rather uncommon and as a consequence gene flow between colonies is probably limited.

Early in March 1952, Dr. and Mrs. David Schmidt sent us by air mail six live specimens of *Melongena corona corona* Gmelin from Punta Rassa, Florida. The following notes on the egg laying and development are based on these specimens. The eggs were deposited in light, straw-yellow capsules about 12 mm. in diameter. The capsules were composed of layers of tough, striated, chitinous material and were deposited in strings. Under natural conditions they are attached to rocks, shells or other hard surfaces.

On July 11 the first egg capsules appeared. The temperature of the water at that time was 78° F. Two females observed during oviposition deposited the strings of capsules on the side of the aquarium in the same area. The capsules were attached to a base membrane and the first string was composed of eighteen capsules, the second of fifteen, the third of nine, and the fourth string of only seven capsules. The number of eggs per cap-

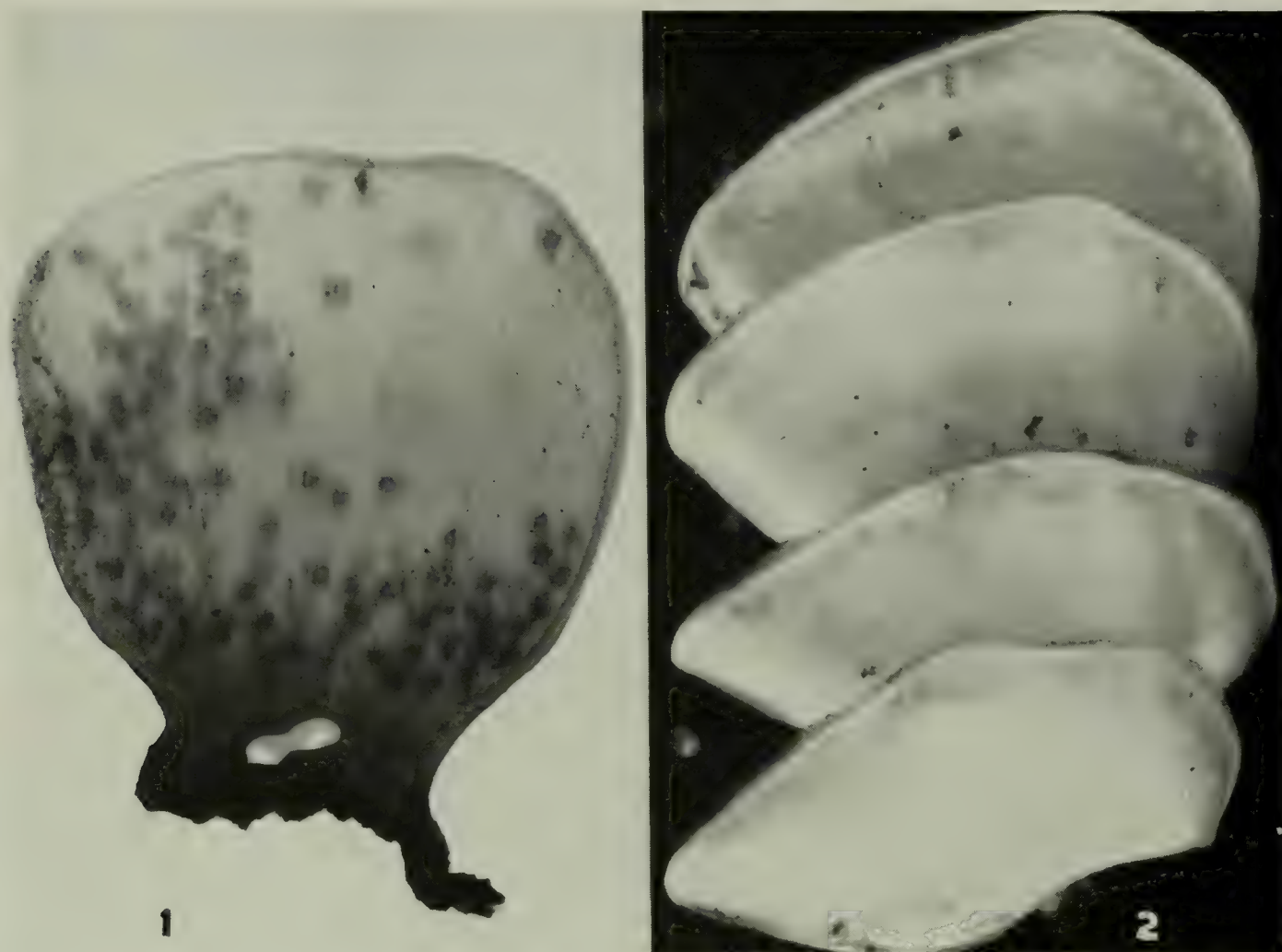


Plate 95. Egg capsules of *Melongena corona* Gmelin, from Punta Rassa, Florida. Fig. 1. A single egg capsule showing the larvae within. Fig. 2. Four capsules in normal arrangement viewed from above and somewhat diagonally. The small ellipse at the top of each capsule is the point at which the capsule eventually ruptures to liberate the young crawling snails (about 6x).

sule varied from 50 to 120. The eggs were contained in a jelly-like mass and were a light yellow in color and opaque. The first cleavage occurred two and one half hours after the capsule had been produced; it was equal and complete. It was impossible to follow the cleavages beyond the sixteen-cell stage on living material due to the large amount of yolk and the consequent opacity of the egg. The early trochophore stage had been reached by the third day and the embryo rotated slowly by means of short, minute cilia. By the seventh day the proboscis and foot began to show and the external kidneys were well developed. The next day a well-developed proboscis, foot and velum were evident as well as the beginning of the tentacles with the eyes at their base. The embryonic heart was first seen pulsating at this time. The shell at this stage is small and cap-like. By the sixteenth day the veliger larvae were well developed. They had four large velar lobes with a double row of strong cilia on their outer edges. The foot and operculum were well developed and the shell had one and one half whorls. The animals were actually showing signs of crawling by the seventeenth day. By the twenty-fifth day the young were actively crawling within the capsule. The velar lobes were still very active, however, probably functioning as "respiratory organs" to aid in the circulation of the fluid within the capsule and the consequent diffusion of gas through the capsule wall. The gills and siphon were well developed at this time. Specimens twenty-five days old or older, when removed from the capsule, no longer protruded the velar lobes but crawled actively and could rapidly turn over the shell with the aid of the foot. By this time the escape pore in the egg capsule was very thin. The first capsule ruptured on the twenty-seventh day (August 6). Most of the young snails, now incapable of swimming, immediately crawled to the water's edge and appeared to be feeding on the minute organisms along the sides of the tank. There were no nurse eggs and approximately ninety-five percent of all the eggs developed.

The radulae of *Melongena* and *Pugilina* are surprisingly small, but the individual teeth are strong, with large hooked denticles, making a very effective rasping tool. The radula is rachiglossate, consisting of three longitudinal rows of teeth—a central and two lateral

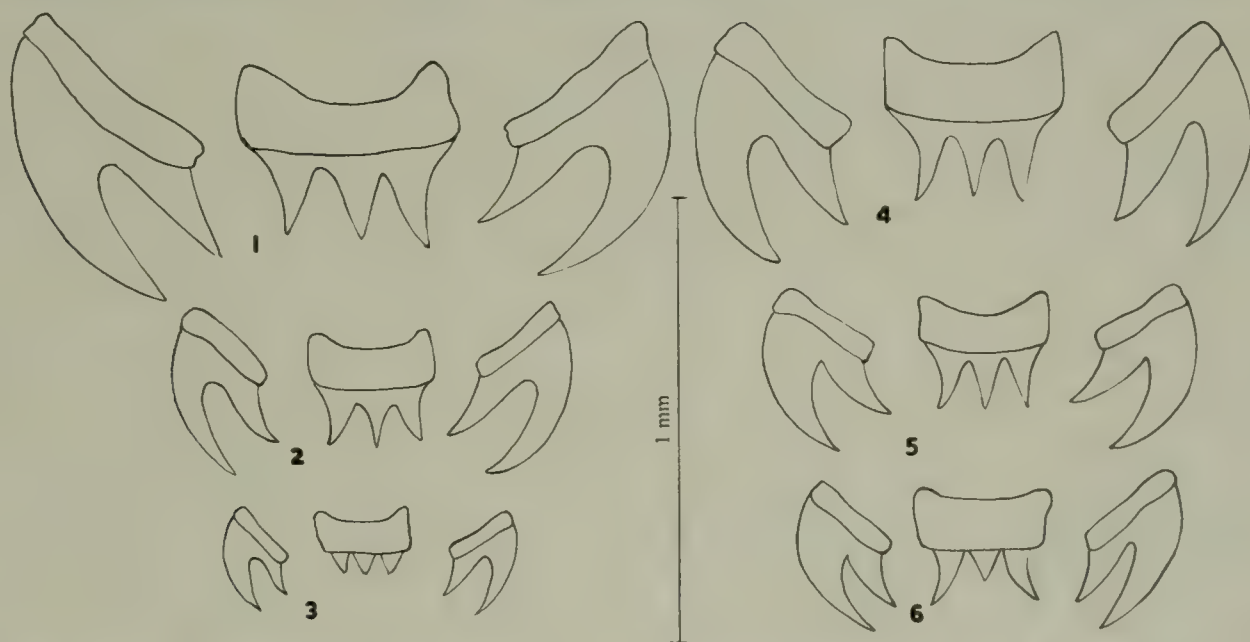
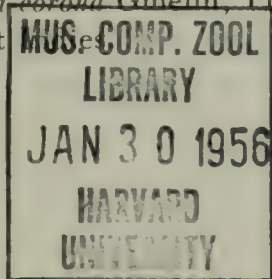


Plate 96. Radulae of *Melongena* and *Pugilina*. Fig. 1. *Melongena melongena* Linné, Cienfuegos, Cuba. Fig. 2. *Melongena melongena* Linné, from a young specimen, Puerto Barrios, Guatemala. Fig. 3. *Melongena bicolor* Say, Grassy Key, Florida. Fig. 4. *Melongena corona johnstonei* Clench and Turner, Little Lagoon, Gulf Shores, Alabama. Fig. 5. *Melongena corona* Gmelin, Punta Rassa, Florida. Fig. 6. *Pugilina morio* Linné, Ministere Bay, Tobago Island, West Indies.



rows. The differences between the several species and genera are slight but appear to be constant. The various types are figured on Plate 96. The formula is  $\frac{1}{2} : \frac{1}{3} : \frac{1}{2}$ .

The proboscis is long and can be greatly extended when the need occurs, such as when feeding on oysters or other bivalves. In the laboratory, a three-inch specimen was able to reach a small piece of fish placed in the bottom of a six-inch test tube. The proboscis was so greatly extended that it became nearly transparent and it was possible to see the minute bits of fish carried along toward the esophagus. Wilcox (1897, p. 27) describes the feeding of *Melongena corona* under natural conditions.

According to Dall (1890, p. 118) *Melongena* is first recorded from the Eocene in the Vicksburg Limestone. Dall's *Melongena sculpturata*, which he described from the Miocene of Ballast Point, Florida, appears to us to belong to the genus *Pugilina*, as does *M. antillarum* Gabb from Santo Domingo. *Melongena corona* first appeared in the Caloosahatchee marl of the Lower Pliocene. There appears to be little or no difference between these Pliocene specimens and those taken in certain areas of southwest Florida at present.

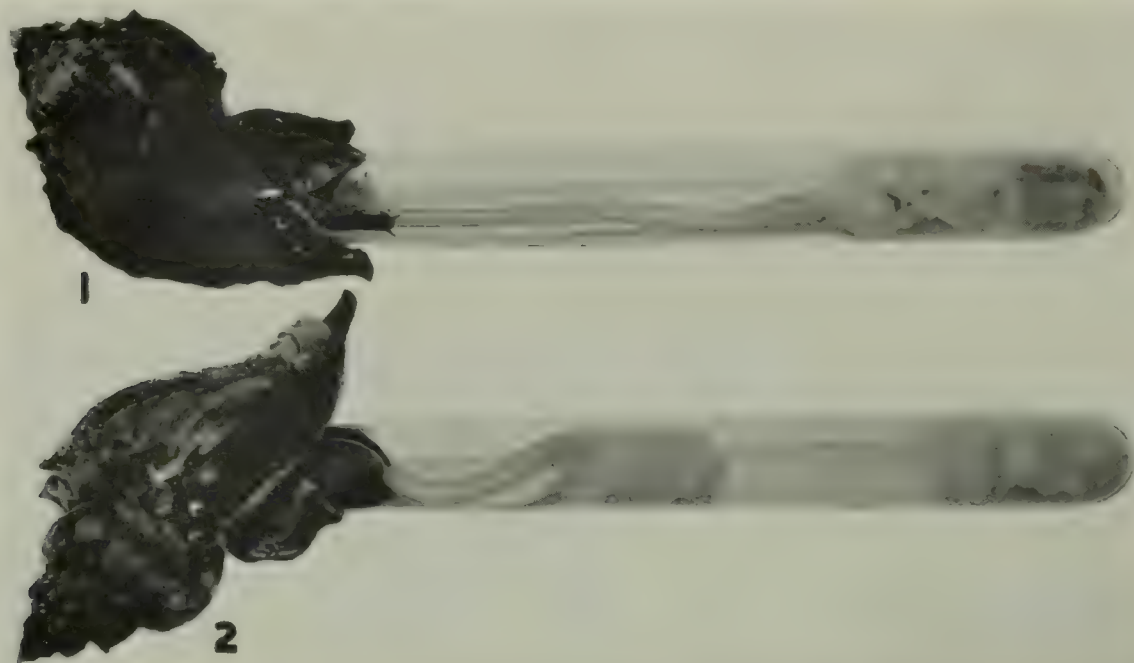


Plate 97. *Melongena corona* Gmelin feeding on a piece of fish placed at the bottom of a six inch test tube. In Fig. 1, the head may be seen inside the test tube with the proboscis fully extended to reach the fish. In Fig. 2, the *Melongena* having grasped the food has pulled a piece part way up the tube for easier feeding. This demonstrates graphically how these animals can so effectively feed on clams (reduced nearly one half).

#### ACKNOWLEDGEMENTS

As with all previously issued numbers in this series, we are deeply indebted to several persons who have aided in many ways to make this study possible. To Dr. and Mrs. David Schmidt of Saron, Wisconsin, we are grateful for live material from several localities in Florida. Their repeated sendings made possible the study of the gross embryology of *Melongena corona*. To Mr. and Mrs. Harry I. Johnstone of Mobile, Alabama, we are indebted for a long series of *Melongena corona johnstonei* from Little Lagoon, Gulf Shores, Alabama, which has established the westernmost record for this genus in the northern Gulf area. To Mr. John H. Butler of Marathon, Florida, we are grateful for specimens of *Melongena bicolor* Say and the notes on their feeding habits. We are also

indebted to C. G. Aguayo, A. C. Bippus, John Finlay, Ruth Merrill, H. A. Pilsbry, J. J. Parodiz, H. A. Rehder and Jeanne S. Schwengel for the loan of material which has aided greatly in obtaining an understanding of the distribution of the various species.

### Genus *Melongena* Schumacher

*Galeodes* Röding 1798, Museum Boltenianum, p. 53; non *Galeodes* Olivier 1791 [Arachnida].

*Melongena* Schumacher 1817, Essai d'un Nouveau Système des Habitations des Vers Testacés, Copenhagen, p. 64, 212.

Type species, *Melongena fasciata* Schumacher (= *Murex melongena* Linné), monotypic.

Shell imperforate, subglobose to elongate and generally solid to massive in structure. Sculpture variable, ranging from smooth specimens to those having as many as four rows of shoulder spines and one row of basal spines. Periostracum usually persistent, yellowish-brown in color and usually sufficiently transparent to show the coloration beneath. Operculum unguiculate with a basal nucleus.

Iredale<sup>1</sup> pointed out that *Volema* Röding had priority over *Melongena*, but at the same time, he designated *Volema paradisiaca* Röding as the type species. This was a fortunate choice as *Volema paradisiaca* (= *Murex ficus* Gmelin) is certainly not congeneric with *Melongena* of the Western Atlantic and Eastern Pacific.

### Subgenus *Melongena* Schumacher

Shell capacious, generally massive in structure and with the later whorls gradually enveloping the earlier whorls, leaving an irregular and somewhat deeply channeled suture and an apparently greatly reduced spire. Spines generally short, broad and spike-like, and usually developed at right angles to the whorl surface with no tendency to recurve toward the spire.

This subgenus is limited in its distribution to portions of the West Indies, both coasts of Central America and the northern coasts of South America.

### *Melongena melongena* Linné

Plates 96 and 98

*Murex melongena* Linné 1758, Systema Naturae, ed. 10, p. 751 (America).

*Galeodes melongena* Linné, Röding 1798, Museum Boltenianum, p. 53.

*Pyrula melongena* Lamarck 1816, Encyclopédie Méthodique (table of plates, p. 8), pl. 435, figs. 3a-e; Lamarck 1822, Animaux Sans Vertèbres 7, p. 140 (l'Océan des Antilles).

*Melongena fasciata* Schumacher 1817, Essai d'un Nouveau Système des Habitations des Vers Testacés, Copenhagen, p. 212 (no locality given).

*Melongena melongena* Linné, Tryon 1881, Manual of Conchology (1) 3, p. 107, pl. 41, figs. 197-198; Bayer 1952, Zoologische Mededelingen 31, p. 268.

*Melongena melongena denudata* Dollfus 1887, Bull. Société d'Études Scientifiques d'Angers (n.s.) 17, p. 56, pl. 2, fig. 3 (Antilles).

*Melongena melongena multispinosa* Dollfus 1887, Bull. Société d'Études Scientifiques d'Angers (n.s.) 17, p. 56, pl. 2, fig. 4 (Antilles).

*Melongena melongena semispinosa* Dollfus 1887, Bull. Société d'Études Scientifiques d'Angers (n.s.) 17, p. 56, pl. 2, fig. 5 (Antilles).

*Melongena margaritana* Richards 1943, Journal of Paleontology 17, pp. 120-123, figs. 1-2 (Pleistocene fossil, Juan Griego, Margarita Island, Venezuela).

<sup>1</sup> Iredale, T. 1917, Proc. Malacological Society London 12, p. 322.

*Description.* Shell reaching 182 mm. (about  $7\frac{1}{2}$  inches) in length, solid and usually spinose. Color white with dark brown to brownish-purple spiral bands of varying widths. Generally there is a broad band from the whorl shoulder to the periphery which is separated by a white area from a much narrower subperipheral band. Below this subperipheral band there are usually numerous thread-like bands, rarely a broad solid band. Whorls  $7\frac{1}{2}$ , strongly convex, particularly above the periphery. Spire somewhat elevated in young specimens, but in the adult stage the spire is depressed, occasionally hardly extending above the top of the body whorl. Aperture subelliptical with a well-developed anal notch and a broad, flattened and short siphonal canal. Parietal lip usually heavily glazed. Palatal or outer lip moderately thin and usually strongly crenulate, particularly below the peripheral area. Columella nearly perpendicular and twisted. Umbilicus nearly always closed by the extension of the parietal callus. Suture canaliculate, the channel becoming fairly broad in large specimens. Occasionally the later whorls are folded over the earlier whorls. The broadening of the channel is sometimes due to the presence of spines on the previous whorl that were developed ahead of the area of the anal canal. Sculpture consisting of spiral rows of strong spines. Usually there are two or three rows above and one row below the periphery near the base of the shell. Occasional specimens are completely devoid of spines and others may have but few. Young specimens very frequently show a rather well-developed sculpture of small spiral threads. The young specimens and the early whorls of the adult are usually strongly nodulose. As the shell advances in age the nodulose costae disappear or are resolved into spines. Operculum horny, unguiculate, rather solid, with the nucleus at the lower end, and sculptured with rather strong concentric lines of growth. Lower surface of the operculum with a large muscle scar which has a smooth shiny margin and a dull rugose central area. Periostracum quite smooth, dull and having exceedingly fine axial growth lines.

length	width *	
182 mm.	144 mm.	Bay of Cárdenas, Cuba
179	131	Jamaica
97	71	Monte Cristi, Santo Domingo

\* not including the spines

*Types.* It would certainly appear that Linné did not have a specimen of *Melongena melongena* in his collection at the time the original description was written. There is, however, no question as to what species he was dealing with, as his references are mainly to recognizable figures of this common West Indian species. We here select Bonanni 1684, *Recreatio*, fig. 186, to be the type figure, for this was Linné's first reference. As Linné gave only America in his original reference we here limit the type locality to Kingston, Jamaica. Hanley (1855, p. 298, *Ipsa Linnaei Conchyliæ*) states that Linné's reference to Lister "was correctly referred to in the review copy" (i.e., the interleaved copy of the 12th edition that Linné used for his corrections and additions) and that Jamaica had been added to the label of the specimen then in the Linnean Cabinet, a specimen probably received after the tenth edition had been published. The holotype of *M. margaritana* Richards is in the Academy of Natural Sciences, Philadelphia, no. 14931, from Juan Griego, Margarita Island, Venezuela, a Pleistocene fossil.

*Remarks.* *Melongena melongena* Linné and *Melongena patula* Broderip and Sowerby are exceedingly close in their relationship. In general, *M. melongena* never reaches the

size that is exhibited by *M. patula*. Also, *M. patula* is much darker in coloration. *M. melongena* may lack spines or have as many as four rows of spines, while *M. patula*, which also may be without spines, never has more than one row, and this is composed of relatively few spines. There is considerable variation in the number of rows of spines in *M. melongena*, even among specimens obtained from a single locality. We have a large series from Monte Cristi, Santo Domingo, containing specimens which are completely smooth and others which have up to four rows of rather large spines.

The distribution of this species in the West Indies is rather remarkable. It appears to be limited to Cuba, the Isle of Pines, Jamaica and Hispaniola. It does not occur in the Bahamas or in Puerto Rico. In the Lesser Antilles it occurs only in Trinidad and Tobago which are on the continental shelf of South America. This is true in part for the records we have from the Bay Islands and Curaçao. These island groups are beyond the continental shelf but they do lie close in, being only a few miles off the coast. A few of the earlier records are certainly open to question, like those given by Krebs (1864, p. 18) for the Virgin Islands and Lesser Antilles. Records from the Florida Keys and the Texas coast are certainly in error (Dall 1889, p. 112). It must be understood that many of the early published records were based upon guesses as to the locality; once in print, they were continually copied until challenged or completely disproved. This was a fault of the times rather than an intent to mislead. Locality data at that time were only of casual interest, perhaps added as an afterthought to the all important *name* of the specimen. Today the name of a specimen is certainly the least important of all data associated with it. It is the only thing that can be changed without destroying the real factual data associated with a specimen. Accurate locality data are the only basis upon which ranges can be established and the ranges of many species considered together outline patterns of distribution allowing us to define faunal regions.

*Melongena melongena* Linné occurs usually in places where there is a moderate ad-

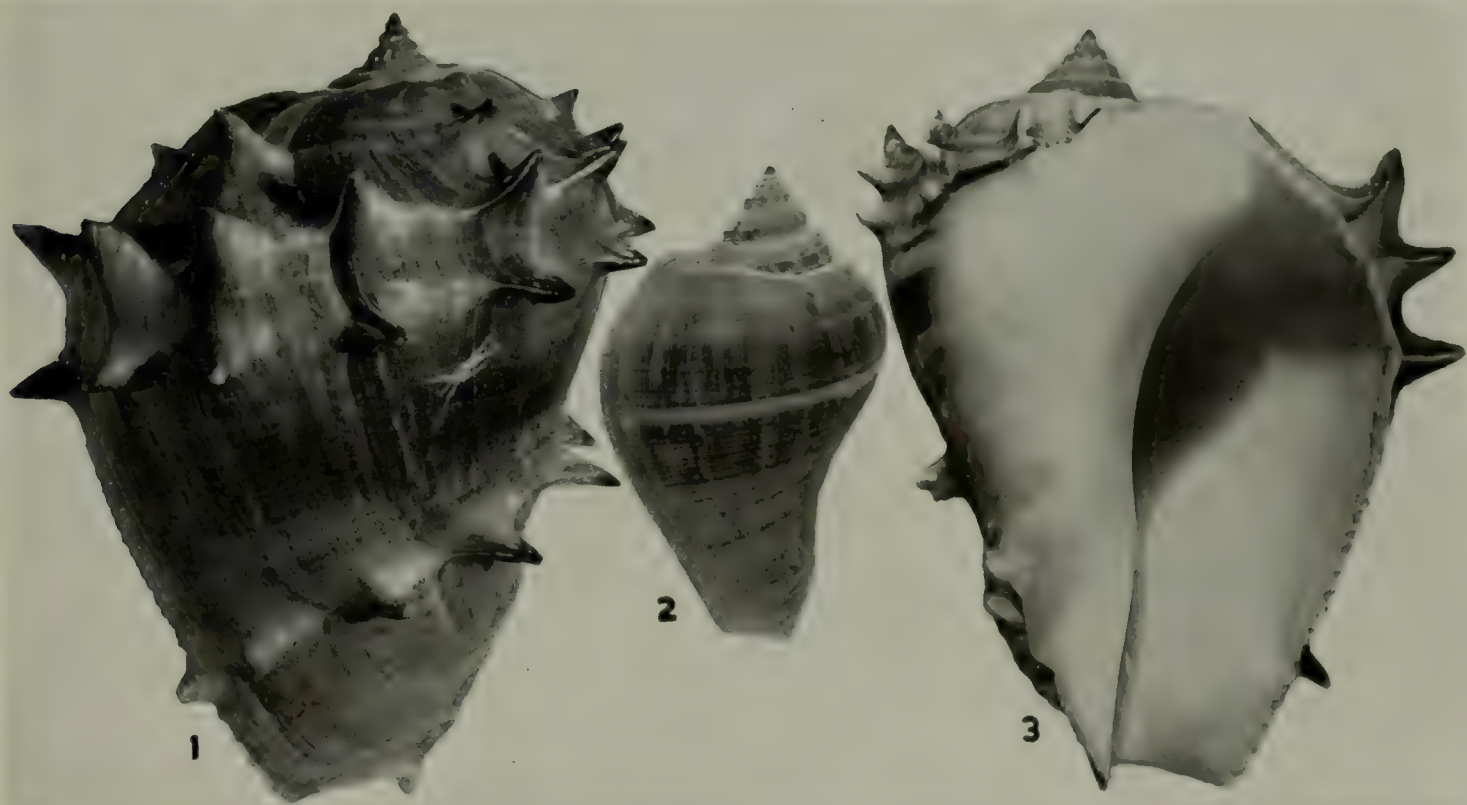


Plate 98. *Melongena melongena* Linné. Figs. 1-3. Hicacos Peninsula, Cárdenas, Cuba. Fig. 1 (3/5x). Fig. 2 Young specimen (natural size). Fig. 3 (2/3x).

mixture of fresh and salt water, such as at the heads of bays where enough freshwater enters to produce a somewhat brackish condition.

This species was probably used for food by the Cuban Indians as specimens now in the Museo Poey, Habana, were found in a kitchen midden at Vertientes, Camagüey, Cuba. The same is true of *Melongena patula*, as many specimens were found in some recent Indian excavations near Balboa, Panama.

The three names given by Dollfus, *denudata*, *multispinosa* and *semispinosa*, apply only to individual forms of *Melongena melongena*, all of which are occasionally found in a single colony. They certainly have no taxonomic value.

*Melongena margaritana* Richards appears to be nothing but a young specimen of *M. melongena* Linné. Richards compares his species with *M. corona minor* Sowerby [= *bicolor* Say] from which, of course, it differs. He stresses the lack of spines as perhaps the most outstanding character of his new form, but the young as well as many adults of *M. melongena* often lack spines.

*Range.* From Tampico, Mexico south and east along the coast of Central and northern South America as far as Dutch Guiana. In the West Indies it occurs only in Cuba, Isle of Pines, Hispaniola, Jamaica and some islands off the coast of South America.

*Specimens examined.* CUBA: Puerto Esperanza; Bahía Honda; Mariel (all Museo Poey); Bahía de Cabañas (MCZ; Museo Poey); mouth of Almendares River (M. Jaume); Batabanaó (MCZ; USNM); Matanzas Bay (Museo Poey); Cárdenas (MCZ; Museo Poey; John Finlay); La Isabela (M. Jaume); Cayo Cristo, Sagua la Grande; Cayo Francés, Caibarién; Rio Damuji, Donastia and La Milpa, Cienfuegos (all MCZ); Nuevitas, Camagüey; Punta Carenero, Puerto Padre (both M. Jaume); Gibara (J. Weber; Museo Poey; USNM); El Cañon, Banes Bay (MCZ); Macabi, Banes Bay (A. Quiñones, Museo Poey); Mouth of Yateras River (MCZ); Rente, Santiago de Cuba (M. Jaume); Guantánamo Bay; Manzanillo (both Museo Poey). ISLE OF PINES: (D. and N. E. Schmidt). HISPANIOLA: Port au Prince and Fort Liberté, Haiti (MCZ; USNM); Monte Cristi and Puerto Plata, Santo Domingo (both MCZ). JAMAICA: Kingston; Black River, St. Elizabeth; Port Royal (all USNM); Port Antonio; Bogue, Montego Bay (both A. Bippus). LESSER ANTILLES: Alley Creek; Ortoire River, Mayaro; Carenage; and Matura Bay, all Trinidad (all H. G. Kugler); Tobago (MCZ). CARIBBEAN ISLANDS: Utila Island, Bay Islands (MCZ); Vignon, Curaçao (USNM). MEXICO: Tampico; 15 miles north of Tecolutla, Vera Cruz (both T. Pulley); Tuxpam, Vera Cruz (M. Bourgeois); Campoton, Campeche (MCZ). GUATEMALA: Livingston (MCZ); Puerto Barrios (Univ. of Michigan; USNM); Punta Manabique (USNM). HONDURAS: Trujillo (MCZ); Puerto Cortez; Tela (both USNM). PANAMA: Colón (USNM). COLOMBIA: near Santa Marta; Sabanilla (both USNM); Cartagena (USNM; MCZ); Puerto Colombia (USNM). VENEZUELA: Isla de Margarita (USNM). BRITISH GUIANA: 4 mi. east of Georgetown (H. G. Kugler). DUTCH GUIANA: Corentyn River (H. G. Kugler).

### *Melongena patula* Broderip and Sowerby

Plate 99

*Pyrula melongena fusco-nigricans* Sowerby 1825, Catalogue of the Shells in the Collection of the Earl of Tankerville, London, p. 62 [*nomen nudum*].

*Pyrula patula* Broderip and Sowerby 1829, Zoological Journal 4, p. 377 (Mazatlan, Mexico).

*Cyrtulus patula* Broderip and Sowerby, Jay 1850, Catalogue of the Shells contained in the collection of John C. Jay, New York, 4th edition, p. 323.

*Cassidulus patula* Broderip and Sowerby, Mörch 1852, Catalogus Conchyliorum Comes de Yoldi, Denmark, p. 103.

*Melongena patula* Broderip and Sowerby, Petit de la Saussaye 1852, Journal de Conchyliologie 3, p. 146.

*Galeodes patula* Broderip and Sowerby, Zetek 1918, Revista Nueva, Panama 5, p. 526 [p. 21 in reprint].

*Galeodea patula* Broderip and Sowerby, Pilsbry and Lowe 1932, Proceedings Academy Natural Sciences, Philadelphia 84, p. 114.

**Description.** Shell reaching 260 mm. (about 10 inches) in length and 190 mm. (about  $7\frac{1}{2}$  inches) in width, solid and usually smooth or only moderately spinose on the whorl shoulder. Color generally of a dark chestnut-brown with a light cream-colored band just below the widest bulge of the whorl. This band may consist of several very narrow bands grouped together. In addition, there may be other spiral bands of the same color, usually thread-like and varying greatly in number. A single specimen that we have seen also shows axial streaks of this cream color. Whorls  $7\frac{1}{2}$  to 8, strongly convex, particularly above the periphery. Spire somewhat elevated in young specimens, but in the adult stage the spire is depressed, occasionally hardly extending above the top of the body whorl. Aperture subelliptical with a rather deep anal notch and a broad, flattened and short siphonal canal. Parietal wall rather heavily glazed. Palatal or outer lip moderately thin and only moderately crenulated. Columella nearly perpendicular and twisted. Umbilicus closed. Suture deeply channeled; occasionally, the later whorls are folded over the early whorls. Sculpture consisting of a single row of spines at the whorl shoulder or none at

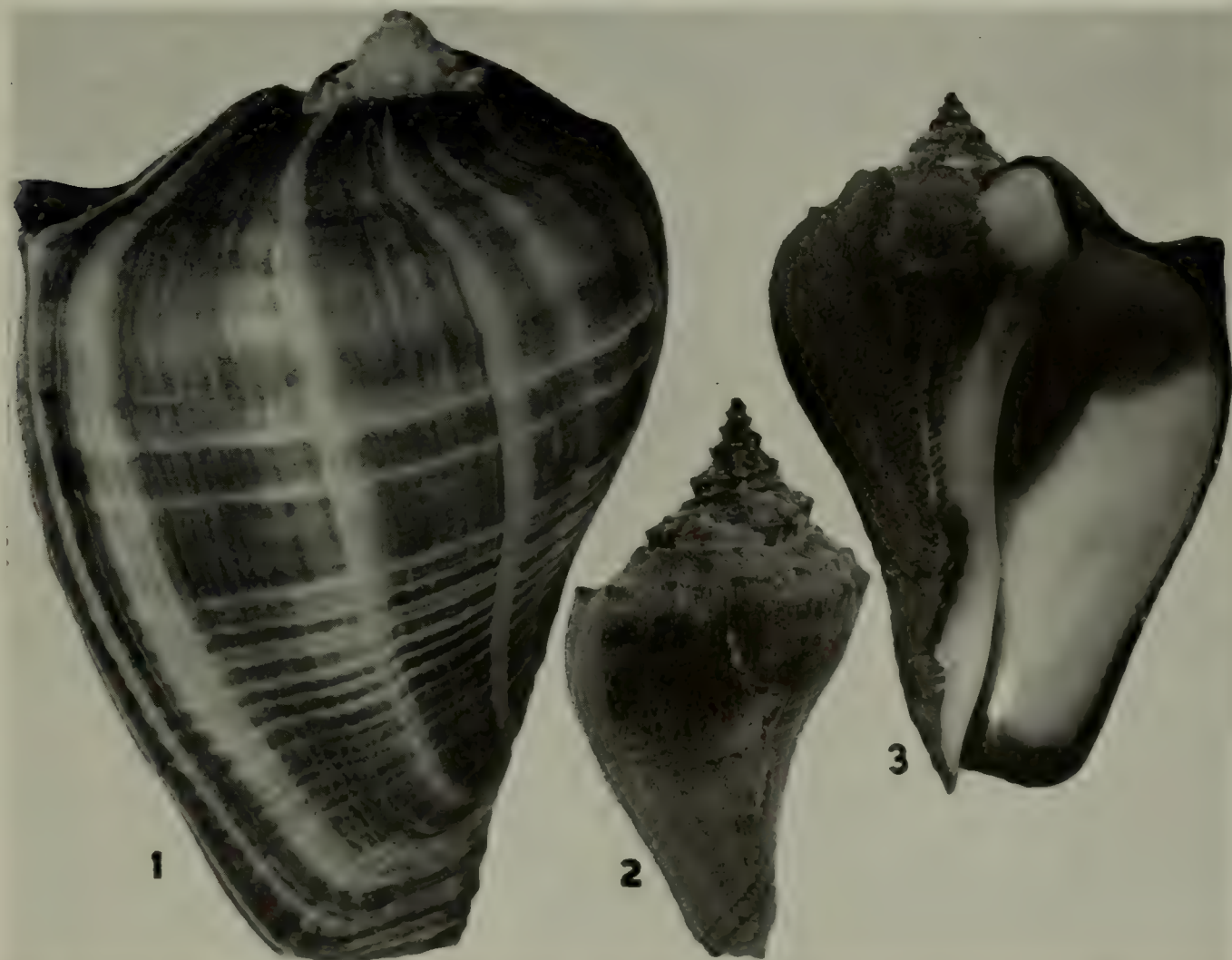


Plate 99. *Melongena patula* Broderip and Sowerby. Figs. 1-3. Guaymas, Sonora, Mexico. Figs. 1 and 3, about  $4/5x$ . Fig. 2. Young specimen (about  $1.3x$ ).

all. Most specimens show numerous and rather fine, spiral, incised grooves developed mainly on the lower half of the shell. Young specimens and the early whorls of adult specimens are usually strongly nodulose. Operculum horny, unguiculate, rather solid with the nucleus at the lower end and sculptured with rather strong concentric lines of growth. The inner surface has a large muscle scar which has a smooth shiny margin and a somewhat roughened and dull central area. Periostracum quite smooth, dull and having exceedingly fine axial growth lines.

length	width	
260 mm.*	190 mm.	Panama
195 *	144	Panama
131 *	98	Mazatlan, Mexico

\* early whorls lost

*Types.* Type specimens of this species are probably in the British Museum. The type locality is Mazatlan, Mexico.

*Remarks.* See also Remarks under *Melongena melongena* Linné.

It is possible that this species was derived from the West Indian *Melongena* and entered the Pacific from the Atlantic during the submergence of the Isthmus of Panama in the late Miocene and early Pliocene times. Today the two forms are differentiated sufficiently to be considered separate species. There are many similar cases of such parallel species in the two oceans, such as *Strombus gracilior* Gray, *Purpura patula panza* Gould, *Barnea subtruncata* Sowerby, and *Pholas chiloensis* Molina of the Pacific and *Strombus pugilis* Linné, *Purpura patula* Linné, *Barnea truncata* Say and *Pholas campechiensis* Gmelin of the Atlantic.

*Range.* Gulf of California from Guaymas, Mexico south to Bahía de Caráques, Ecuador. This southern record is given by Bayer (1952, p. 272).

*Specimens examined.* MEXICO: Guaymas, Sonora (H. R. Turver; A. Sorensen); Mazatlan (MCZ). NICARAGUA: Corinto (Charleston Museum). COSTA RICA: Gulf of Nicoya (MCZ). PANAMA: Chame Bay; Canal Zone (both MCZ); Verrado Beach (C. M. Dumbauld); near Balboa (J. Zetek; MCZ).

### Subgenus *Rexmela* Olsson and Harbison

*Rexmela* Olsson and Harbison 1953, Academy of Natural Sciences Philadelphia, Monograph 8, p. 213.

Type species, *Melongena subcoronata* Heilprin (= *Melongena corona* Gmelin), original designation.

Shell moderate in size to fairly large, generally solid and strong but not massive. Spire extended, the later whorls not enveloping the earlier whorls. Suture not channeled but coarsely imbricate, the imbrications being previous margins of the anal canal. Spines variable, claw-like to spike-like, generally open on their forward margin. They may be produced at right angles to the shell surface but generally they are somewhat parallel to the long axis of the shell, and frequently curve inwardly.

*Rexmela* was introduced as a subgenus, separating the Pliocene *Melongena subcoronata* Heilprin from the recent *M. corona* Gmelin. In our opinion, these two forms are synonymous; in fact, we can duplicate almost exactly the type of *M. subcoronata* with recent specimens from Lossman's Key.

However, the name *Rexmela* is available to use for a subgenus separating *corona*, its subspecies and closely related forms, from *M. melongena* Linné and *M. patula* Broderip and Sowerby, two species quite different from the *corona* complex.

This subgenus is limited in its distribution to Florida, Alabama and the northern tip of Yucatan.

#### The *Melongena corona* complex

The multiplicity of forms in *Melongena corona* Gmelin is quite probably due to factors of isolation of smaller or larger areas along the central and southwest coast of Florida during its geologic history since the Pliocene. This is a region of very low relief and even minor changes in the oceanic level would affect profoundly much of the coast line. Areas of land were invaded by the sea as the oceanic level was raised, new habitats were created and colonies of this species developed as they moved into these new areas. Possibly chance alone brought in a few individuals with a similar gene complex and thus a population evolved that was remarkably uniform. In others, one or more different assemblages invaded a new area and a mixture took place giving rise to a very varied population. A lowering of the oceanic level would have a similar effect, exposing a new land area that would shortly build up the mangrove association or a similar assemblage of a somewhat brackish water fauna and flora.

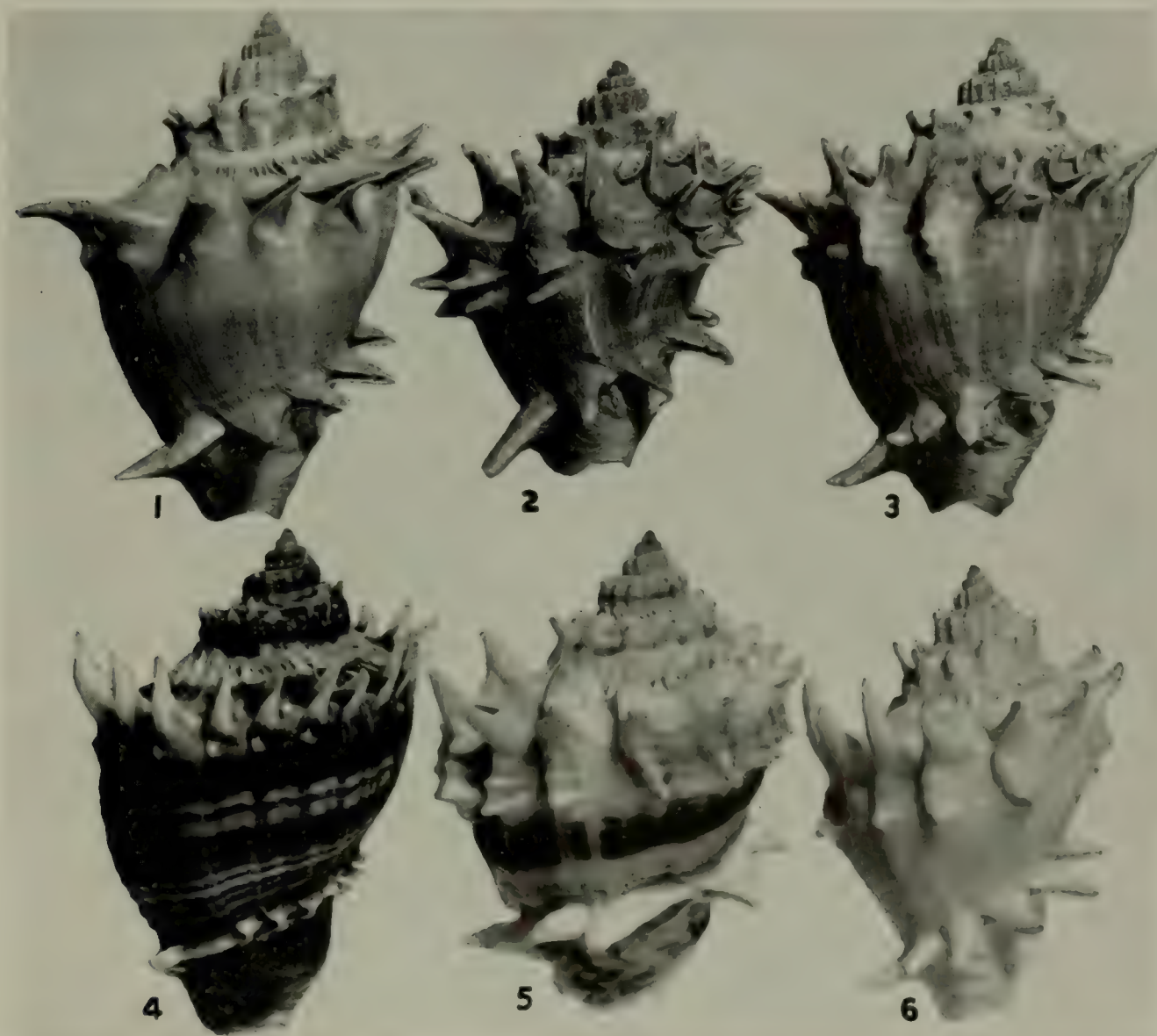


Plate 100. *Melongena corona corona* Gmelin. Figs. 1-3. Barfield Bay, Caxambas, Florida. Figs. 4-5. Pinaire, Pine Island, Lee Co., Florida. Fig. 6. Goodland, Marco, Florida (all 5/6x).

Naturally such changes were slow and as they took place, either as a plus or minus factor of oceanic level, the fauna and flora advanced or retreated. Thus the present situation is perhaps but a picture of much of the past. We are but viewing at this time a medley of colonies or populations that have been forced to move back and forth: some maintaining a certain genetic purity, others becoming thoroughly mixed by the vicissitudes of chance introductions.

The area of greatest disturbance appears to be between Tampa Bay and Cape Sable. North of Cedar Keys *Melongena* exhibits a fine example of a cline, ending at Gulf Shores, Alabama as a subspecies which we have called *johnstonei*. Starting at Cape Sable and going east and then north along the east coast of Florida the populations of *Melongena* are very uniform and are considered here as the subspecies *altispira*. The Keys, from Key Largo to the Tortugas possess another species, *Melongena bicolor* Say, which is remarkably uniform.

### *Melongena corona corona* Gmelin

Plates 94-97; 100-103

*Murex corona* Gmelin 1791, *Systema Naturae*, ed. 13, p. 3552 (Sinu Mexicano).

*Melongena belknapi* Petit de la Saussaye 1852, *Journal de Conchyliologie* 3, p. 65, pl. 2, fig. 5 (coast of Florida).

*Melongena subcoronata* Heilprin 1887, *Transactions Wagner Free Institute of Science, Philadelphia* 1, p. 70, pl. 1, fig. 3 (Pliocene: Banks of the Caloosahatchie River below Fort Thompson, Florida).

*Melongena corona aspinosa* Dall 1890, *Transactions Wagner Free Institute of Science, Philadelphia* 3, p. 120, pl. 9, fig. 6 (Pliocene: Caloosahatchie Beds, Florida).

*Melongena corona inspinata* Richards 1933, *Nautilus* 47, p. 57, pl. 6, fig. 1 (near Sarasota, Florida).

*Melongena perspinosa* Pilsbry and Vanatta 1934, *Nautilus* 47, p. 120, pl. 12, fig. 1 (Lossman's Key, near Shark River, Florida).

*Melongena corona incurvata* Lermond 1936, *Check List of Florida Marine Shells, Gulfport, Florida*, p. 40 [*nomen nudum*].

*Melongena corona sargenti* Emery and Lermond 1936, *Check List of Florida Marine Shells, Gulfport, Florida*, p. 42 [*nomen nudum*].

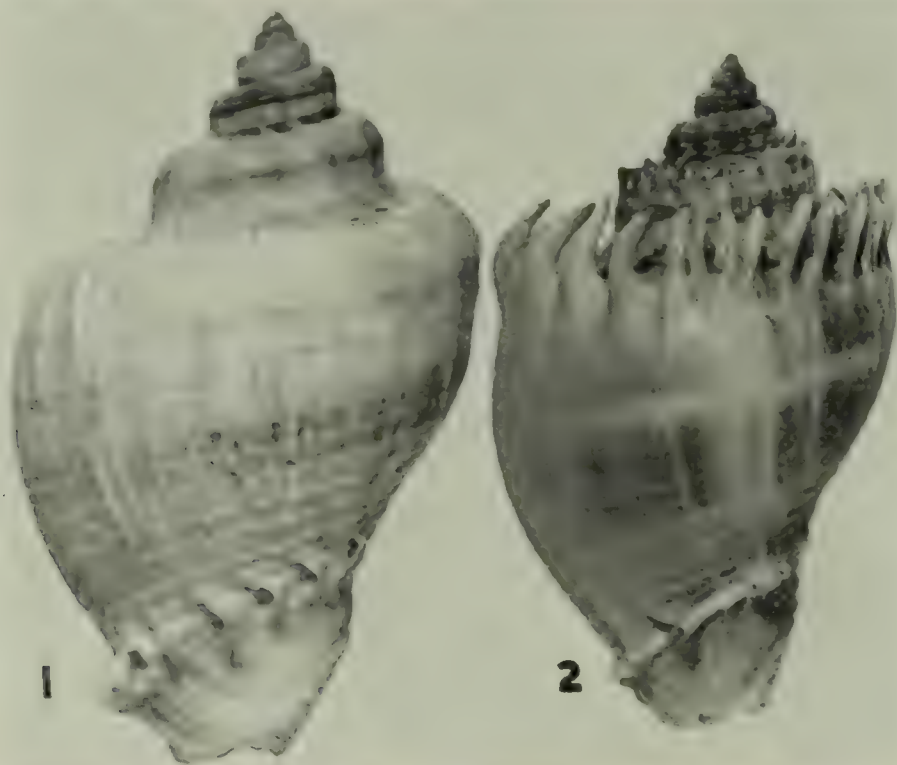


Plate 101. *Melongena corona corona* Gmelin. Fig. 1. Paratype, *Melongena corona inspinata* Richards (= *Melongena corona corona* Gmelin) Palma Sola Key, Florida (natural size). Fig. 2. Boca Ciega Bay, Gulfport, Florida (about 1.3x).

*Melongena corona trinodulosa* Emery and Lermond 1936, Check List of Florida Marine Shells, Gulfport, Florida, p. 40 [*nomen nudum*].

*Melongena corona mulletensis* 'Lermond' VanHyning 1940, A Check list of the Mollusca of Florida, Gainesville, Florida, p. 19 [*nomen nudum*].

*Melongena corona perspectiva* Abbott 1954, American Sea Shells, New York, p. 72. [This was a lapsus for *Melongena corona perspinosa* Pilsbry and Vanatta.]

**Description.** Shell reaching 205 mm. (about 8 inches) in length, fairly thin to relatively thick and solid, and usually sculptured with spines. Color generally ivory with spiral bands of light orange-brown to dark red-brown. These bands are very variable, some specimens having almost a continuous series of bands of varying widths. However, the most widespread pattern consists of three major bands: one at the whorl shoulder, one about at the whorl periphery and a broad band at the base of the whorl. Whorls 7, rather convex and shouldered. The shoulder is usually horizontal and rather narrow: occasionally it may be broad and with a downward slope. Spire subdepressed to extended. Aperture subovate. Outer lip thin and usually crenulated. Inner lip usually consisting of a thin callus, but in old specimens it becomes thick and white in color. Columella rather broad and twisted. Umbilicus glazed over by the parietal shield. Suture relatively inconspicuous, generally a little more pronounced on the earlier whorls. Sculpture exceedingly variable. Usually there is a single row of rather large spines at the whorl shoulder and another at the base of the whorl. However, occasional colonies may have specimens ex-

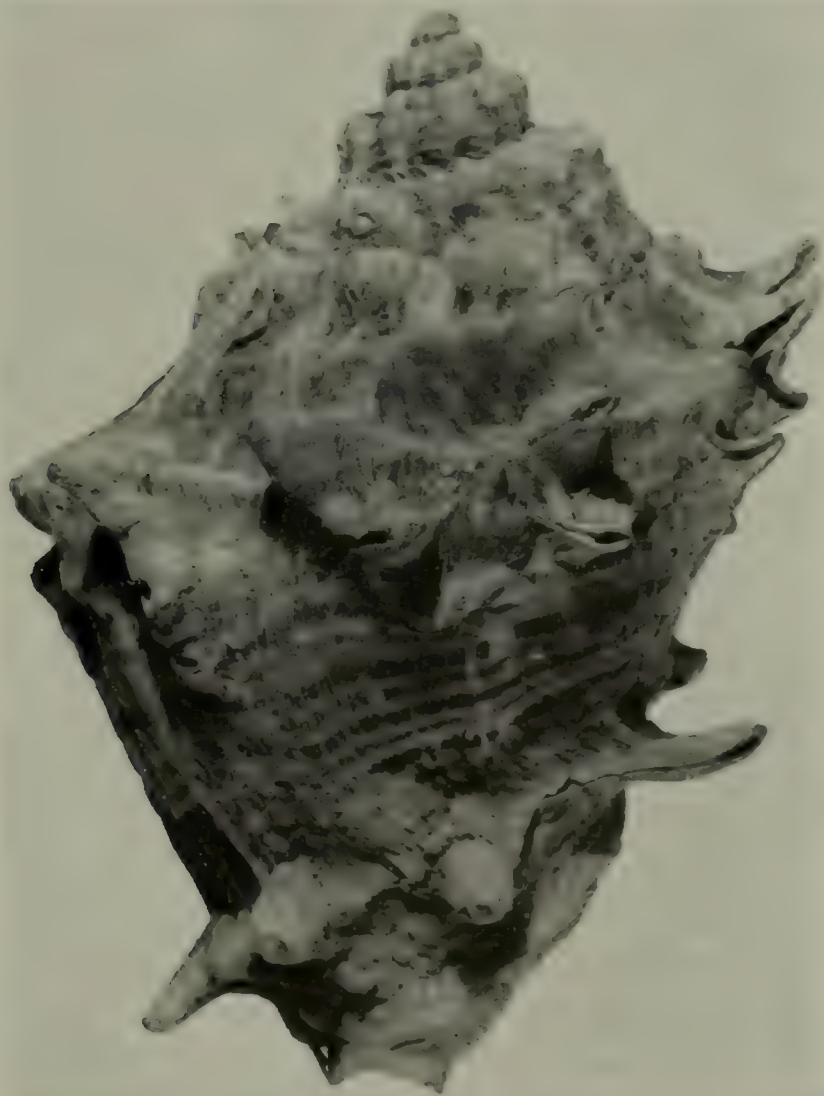


Plate 102. *Melongena corona corona* Gmelin. Holotype, *Melongena perspinosa* Pilsbry and Vanatta (= *M. corona* Gmelin), Lossman's Key, Florida (about 1.1x).

hibiting the large shoulder spines and one to two rows of smaller spines immediately below: in addition, there is sometimes a row of smaller spines between the shoulder series and the suture. In other colonies the spines may be reduced to a single row at the whorl shoulder, the basal row being absent. In various colonies the spines may project at right angles to the shell axis, or more commonly project upwardly and may even be arched toward the spire. There is a great deal of variation in the number of large shoulder spines, these ranging from 10 to 26 on the body whorl. Generally the spines are claw-like in appearance and are open on the forward side. Occasionally these spines are closed, at least near the base, especially in colonies from the region between Cape Romano and Lossman's River. At the suture there is a series of imbrications representing the previous growth stages of the anal canal. These are most conspicuous on the last three whorls. In addition to the spiral rows of spines there are numerous spiral ridges which vary in their intensity between colonies. The early whorls are generally rather strongly axially costate. Operculum unguiculate, the nucleus basal, the outer surface with numerous and exceedingly fine concentric ridges. Inner surface with the palatal margin smooth and glazed, and the inner area with a series of rather widely separated concentric ridges which appear shingled. Periostracum usually colored a dark and dull greenish-brown to a dull red-brown.

length	width *	
205 mm.	127 mm.	Goose Cove, Cedar Keys, Florida
187	123	Big Carlos Pass, Sanibel Island, Florida
138	95	Lossman's Key, Florida
98	70	Holotype of <i>M. perspinosa</i> P. and V.

\* not including spines

*Types.* It is practically certain that Gmelin had no specimens of this species, his description being based on the Latin diagnosis and figures in Chemnitz. We here select Chemnitz's figure in the Conchylien-Cabinet 1788, (1) 10, pl. 161, fig. 1527 as the type figure. The type locality was given originally as the Gulf of Mexico. We here restrict it to Tampa Bay, Florida, as possibly the area from which this material may have come. The type of *Melongena belknapi* Petit de la Saussaye is in the collection of the Journal de Conchyliologie. The holotypes of *M. subcoronata* Heilprin and *M. perspinosa* Pilsbry and Vanatta are in the Academy of Natural Sciences, Philadelphia. The holotype of *M. corona inspinata* Richards is in the collection of Mrs. E. R. Edgerly, Trenton, New Jersey: paratypes are in the Academy of Natural Sciences, Philadelphia. The holotype of *Melongena corona aspinosa* Dall is in the United States National Museum, no. 135319.

*Remarks.* The life history of this species is exceedingly interesting and much of it accounts for the variation exhibited by the typical form. Through the kindness of Dr. and Mrs. David Schmidt we were able to get live material for our studies. *Melongena corona* breeds in the summer months, starting in early July. Live specimens were received in March and placed in an aquarium. They continued to be active throughout the spring and on July 11, laid the first egg capsules. Their gross embryology was followed daily. Each day a capsule was cut open and the young examined. In this way a study was made from the initial egg stage to the young snail that emerged from the capsule, as described in the introduction. All stages in the development are passed within the capsule, from the egg through the trochophore and veliger larvae, and the young finally emerge as very

small but nevertheless fully developed crawling snails. Naturally, egg capsules attached to objects subject to mechanical movement may be dispersed, but in the main, the young are very closely associated with the region where they were produced. From a purely genetic standpoint this would account for the general uniformity of many colonies and also for the variation shown by other colonies. Species which possess free-swimming larvae are generally quite constant in their characters over most of their range, much depending, of course, on the length of larval life and the ability of water currents as a dispersal factor.

According to Dall (1890, p. 118) various members of the Melongenidae appeared in America in the Upper Eocene. So far as we can trace *Melongena* appeared in the Pliocene of central Florida. There seems to be no difference between the recent *Melongena corona corona* Gmelin and the Pliocene *M. subcoronata* Heilprin. Our figure of a specimen from Lossman's Key, Florida (Plate 103, fig. 1) is almost an exact replica of the figure given by Heilprin for his *subcoronata*. We have other specimens from Fort Myers Beach, Florida which are also nearly identical with Heilprin's figure.

*Range.* The subspecies *M. c. corona* extends from Keaton's Beach, Taylor County, Florida south to the north end of Cape Sable, Florida.

*Specimens examined.* FLORIDA: Lossman's Key, Ten Thousand Islands (D. and N. Schmidt; MCZ; USNM); Plover Key, 5 mi. north-northwest of Lossman's River, Monroe Co.; Allen River, Everglades, Collier Co. (both MCZ); Pavilion Key (Carne-

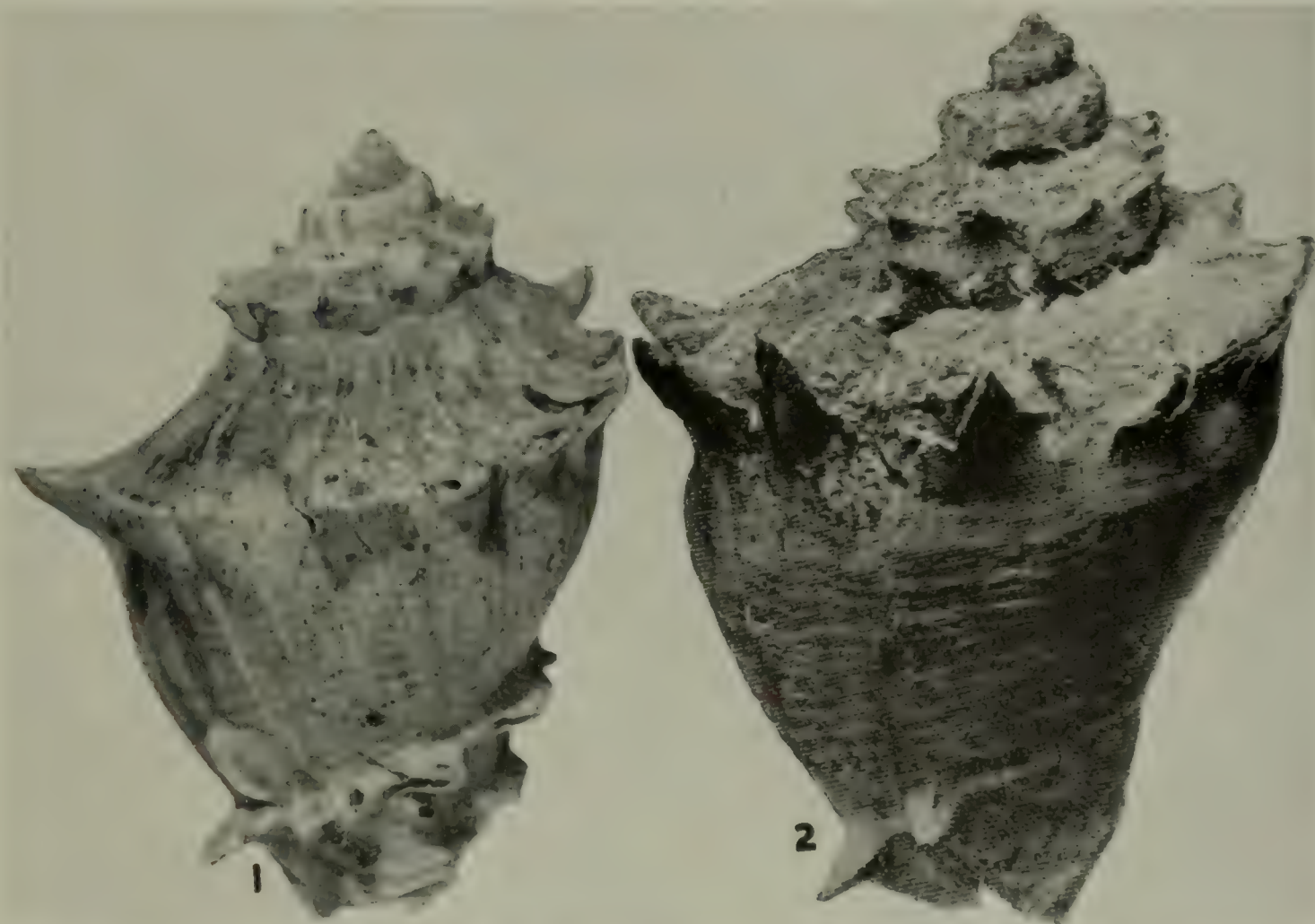


Plate 103. *Melongena corona corona* Gmelin. Fig. 1. Lossman's Key, Ten Thousand Islands, Monroe County, Florida (1.1x). Fig. 2. Holotype, *Melongena subcoronata* Heilprin (= *M. corona* Gmelin) from Heilprin 1887, pl. 1, fig. 3 (about natural size).

gie Museum); Cape Romano (D. and N. Schmidt); Horse Key,  $1\frac{1}{2}$  miles southeast of Marco, Collier Co. (MCZ); Marco Island (D. and N. Schmidt; R. Merrill; J. Schwengel; M. Branham); Gordon River, Naples (D. and N. Schmidt); Barfield Bay, Naples (R. Cahoon; D. and N. Schmidt); Bonita Beach, Bonita Springs (MCZ; D. and N. Schmidt); Estero Island (R. Merrill; D. and N. Schmidt; USNM); Punta Rassa (R. Merrill; D. and N. Schmidt; USNM; MCZ); Caloosahatchee River, Port Comfort (D. and N. Schmidt); Mouth of Alligator Creek, Charlotte Harbor (MCZ); Sanibel Island (J. Schwengel; R. Merrill; USNM; MCZ); Causeway to Mattacha Pass and Pine Island (G. Weber); Bokeelia Beach, Pine Island (D. and N. Schmidt; G. Weber); Pineaire, Pine Island; St. James, Pine Island (both D. and N. Schmidt); Boca Grande (H. Dodge); Gasparilla (Florida State Museum); Johnson Cove and Cedar Point, Lemon Bay (both MCZ); Englewood Beach (R. Merrill); Venice; Casey's Key, Manatee Co. (both Carnegie Museum); Mouth of North Creek, Little Sarasota Bay; Upper end of Little Sarasota Bay,  $5\frac{1}{2}$  miles south of Sarasota (both MCZ); Sarasota (MCZ; R. Cahoon); Manatee River (MCZ); Palma Sola Bay, Manatee Co.; Anna Maria Key, Bradenton (both D. and N. Schmidt); Long Key, near Pass-a-grille; Mullet Key, St. Petersburg; Clam Bayou, Boca Ciega Bay, Gulfport; Big Bayou and Monte Cristo Island, St. Petersburg; Piney Point, Lower Tampa Bay (all MCZ); Rocky Point and Safety Harbor, Tampa Bay (both Florida State Museum); Seminole Pier, Clearwater Bay (G. Weber); Davis Causeway, Clearwater (MCZ); St. Josephs Sound, Dunedin (G. Weber); Tarpon Springs (J. Weber); Bayou between Green Key and Port Richey (G. Weber); Crystal River (H. and K. Johnstone); Sea Horse Key, Cedar Keys (MCZ); Goose Cove, Cedar Keys (S. Whitman); Horseshoe Point, Dixie Co. (T. Pulley); Keatons Beach (D. and N. Schmidt).

**Melongena corona altispira** Pilsbry and Vanatta  
Plate 104

*Melongena corona altispira* Pilsbry and Vanatta 1934, Nautilus **47**, p. 119 (Oceanus, Brevard Co., Florida).

*Description.* Shell reaching 72 mm. (about 3 inches) in length, thin but strong, and generally sculptured with spines. Color generally ivory with chocolate brown bands, one at the whorl shoulder, the second at the whorl periphery, and the third at the base of the whorl. These bands appear to be quite constant. Whorls 7, convex and shouldered. The shoulder is usually horizontal and narrow. Spire somewhat elevated. Aperture subovate. Outer lip thin and finely crenulate. Inner lip consisting of a rather thin callus. Columella broad and twisted. Umbilicus glazed over by the parietal shield. Suture relatively inconspicuous. Sculpture variable. In this form there is usually but a single row of small and rather numerous spines at the whorl shoulder. However, many specimens occur, particularly in the Cape Sable area, that are devoid of spines, though others in the same colony may have a single row at the whorl shoulder. These spines project upward and are seldom arched. An occasional specimen will show a row of weak and small spines at the base of the shell. There are numerous and fine spiral ridges which are a little stronger near the base. The early whorls are strongly and axially costate. Sutural imbrications are only weakly developed. Operculum similar to that of the typical form. Periostracum very thin and a dull brownish in appearance.

length	height	whorls	
71.0 mm.	41.0 mm.	8	Mosquito Lagoon, Oak Hill, Florida
70.5	44.0	7	Matanzas Inlet, St. Augustine, Florida
70.0	40.5	8	Cocoa, Florida
58.0	33.5	7	7 miles W. of Flamingo, Florida

*Types.* The holotype of *Melongena corona altispira* Pilsbry and Vanatta is in the Academy of Natural Sciences, Philadelphia, no. 72490. The type locality is Oceanus, Brevard County, Florida.

*Remarks.* This subspecies does not appear to be abundant anywhere throughout its range to judge from the collections we have seen. It appears to be a direct offshoot of *M. corona corona*. Actually, the type series described by Pilsbry and Vanatta are atypical for the subspecies. They appear to be specimens that may have existed under hypersaline conditions, a habitat which frequently causes distortion in shell structure.

We possess other specimens of this subspecies from Oceanus that are very similar to the normal form which exists along the entire east coast of Florida. They were obviously not from the same ecological spot.

Many specimens of this subspecies are devoid of spines, others are weakly spinose and in still others the shoulder spines are exceedingly irregular in their development. The basal row of spines is weak and generally lacking.

We have seen specimens at two localities on the southwest coast that apparently belong to this subspecies. These reached Marco Island and Cape Romano probably by drifting from the Cape Sable region.

This subspecies differs from typical *corona* by being on the average a little smaller, having but a single row of shoulder spines which are weakly developed and frequently absent. The basal row of spines on *altispira* is usually lacking, but when it is present there are always shoulder spines in addition.

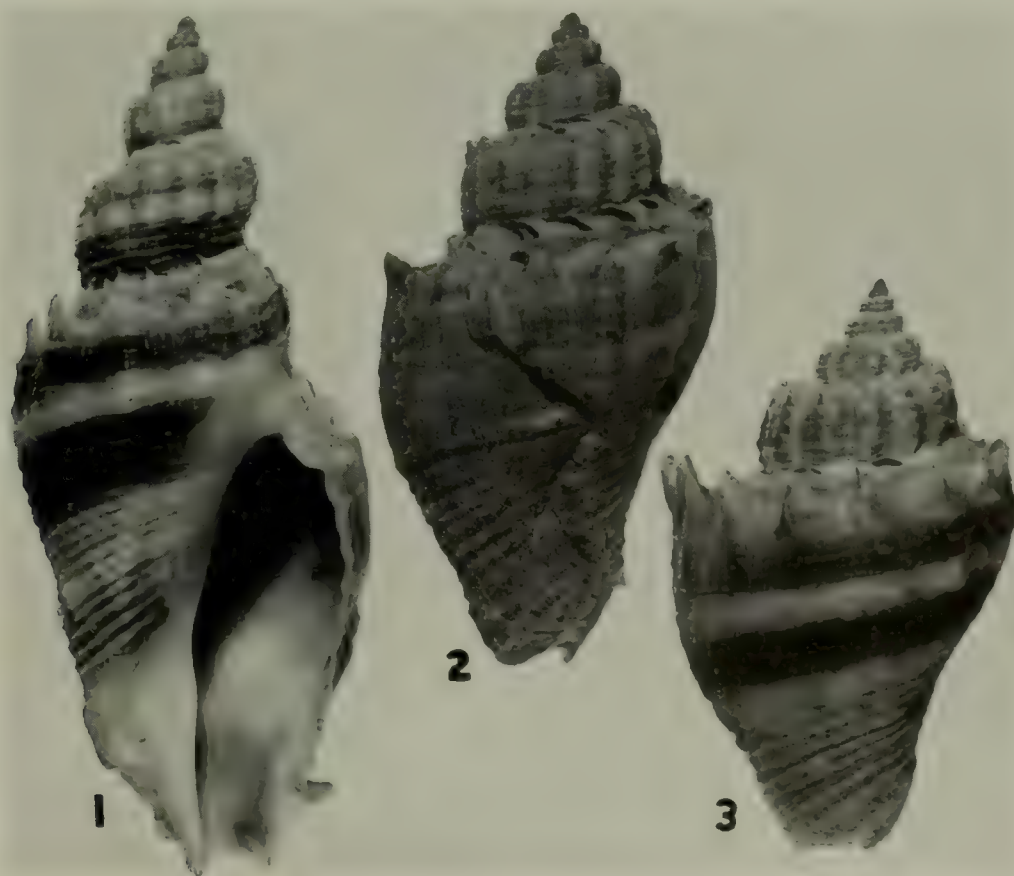


Plate 104. *Melongena corona altispira* Pilsbry and Vanatta. Fig. 1. Holotype, Oceanus, Florida. Fig. 2. Banana River, 2 miles east of Coco Beach, Florida. Fig. 3. New Smyrna, Florida (all about 1.3x).

We have not detected any evidence of a true cline along the east coast of Florida in this subspecies. Perhaps the data at hand are still insufficient. On the other hand, until the inland water way was made continuous, there were many stretches, some long ones, that offered only the open ocean as a highway, areas quite unsuitable for *Melongena* and, in addition, having coastal currents that trend southwards rather than to the north. Our most northern record, Matanzas Inlet, was based upon a single dead shell and this may well be a recent introduction into this area. The Florida portion of the inland waterway needs far more study, both in the dredged cuts as well as along the entire Indian "River" area where only a boat channel was dredged.

See also Remarks under *M. bicolor* Say.

*Range.* This subspecies extends from the region of Cape Sable, Florida in the south, to the east and north as far as Matanzas Inlet near St. Augustine.

*Specimens examined.* FLORIDA: Matanzas Inlet, 15 miles south of St. Augustine; Daytona Beach; New Smyrna (all MCZ); Mosquito Lagoon, near Oak Hill (USNM); Indian River, Cocoa, Brevard Co. (USNM; MCZ; J. Schwengel); Ocean Beach, Brevard Co. (Carnegie Mus.); Oceanus, Brevard Co. (ANSP; MCZ); Eau Gallie (MCZ); Sebastian (R. Merrill); St. Lucy Inlet (J. M. Cannon); Virginia Key, Miami (J. Weber); Matheson Hammock, Biscayne Bay (R. Merrill); Coral Gables (J. Weber; R. Merrill); Coconut Grove; Key Largo Station, Key Largo (both MCZ); Barnes Sound, Key Largo (J. Weber); Madeira Bay (MCZ); 7 miles west of Flamingo, Cape Sable (D. and N. Schmidt); Sandy Key, Cape Sable (MCZ; J. Schwengel); Marco Island; Cape Romano (both D. and N. Schmidt).

***Melongena corona johnstonei*, new subspecies**

Plates 96 and 105

*Description.* Shell reaching 171 mm. ( $6\frac{3}{4}$  inches) in length, rather solid and strongly sculptured. Color generally pale ivory overlaid with two or three bands of dark chocolate-brown which coalesce in the adult forming an almost solid brown shell. In some specimens the brown bands persist in the adult and these are best observed in transmitted light as seen from within the aperture. Whorls  $7\frac{1}{2}$  to 8, rather strongly convex and shouldered. Spire extended. Aperture subovate. Outer lip fairly thin and rather finely crenulate. Inner lip usually consisting of a thin to fairly thick callus. Columella broad and twisted. Umbilicus glazed over by the parietal shield. Suture relatively inconspicuous. Sculpture consisting usually of a single row of strong, erect or recurved spines on the margin of the whorl shoulder. Rarely there exists a rather weak series of spines near the base of the shell. In addition to the spines there are numerous fine spiral ridges which are strongest near the base. At the suture there are numerous imbrications representing previous growth stages of the anal canal. Operculum as in the typical form. Periostracum thin and a dull greenish-gray in color.

length	width	whorls	
171 mm.	94.0 mm.	8.0	Paratype
126	76.0	8.0	Port St. Joe, Florida
102	54.0	7.5	Holotype
94	56.5	7.5	Pensacola, Florida
83	51.0	7.0	Panacea, Wakulla Co., Florida

**Types.** Holotype, Museum of Comparative Zoölogy, no. 189687, from Little Lagoon, Gulf Shores, Alabama. Paratypes from the same locality in the Museum of Comparative Zoölogy, the United States National Museum, the Academy of Natural Sciences, Philadelphia, the Florida State Museum, the Alabama Museum, and the Collections of Harry and Kathleen Johnstone, David and Nevada Schmidt, and D. Thaanum.

**Remarks.** This subspecies has a very limited distribution in northern Florida and extreme eastern Alabama. It appears to merge more or less with the typical form in the region of Apalachee Bay, Florida. It differs in being more elongate, in being in general much darker in color, and in having a brown coloration well diffused over most of the shell leaving a few narrow, spiral bands of white. The shoulder is generally broader than in *M. c. corona*, and the shoulder spines are vertical and more generally pointed inwardly toward the spire.

At Little Lagoon, Gulf Shores, Alabama, *M. c. johnstonei* were feeding on *Ensis minor* Dall and *Tagelus divisus* Spengler. They would locate these bivalves and then extend their proboscises down into the burrow and clean them out. Dead specimens of these two species were the only common bivalves in the beach drift and *Melongena corona johnstonei* was the only large gastropod that we collected along two miles of shore line.

This subspecies exhibits a smooth cline. The gradient of change starts above or along the area of Dead Man's Bay, which is the "bight" area of north central Florida on the west coast. Transitional elements with *M. c. corona* appear in this region. As colonies

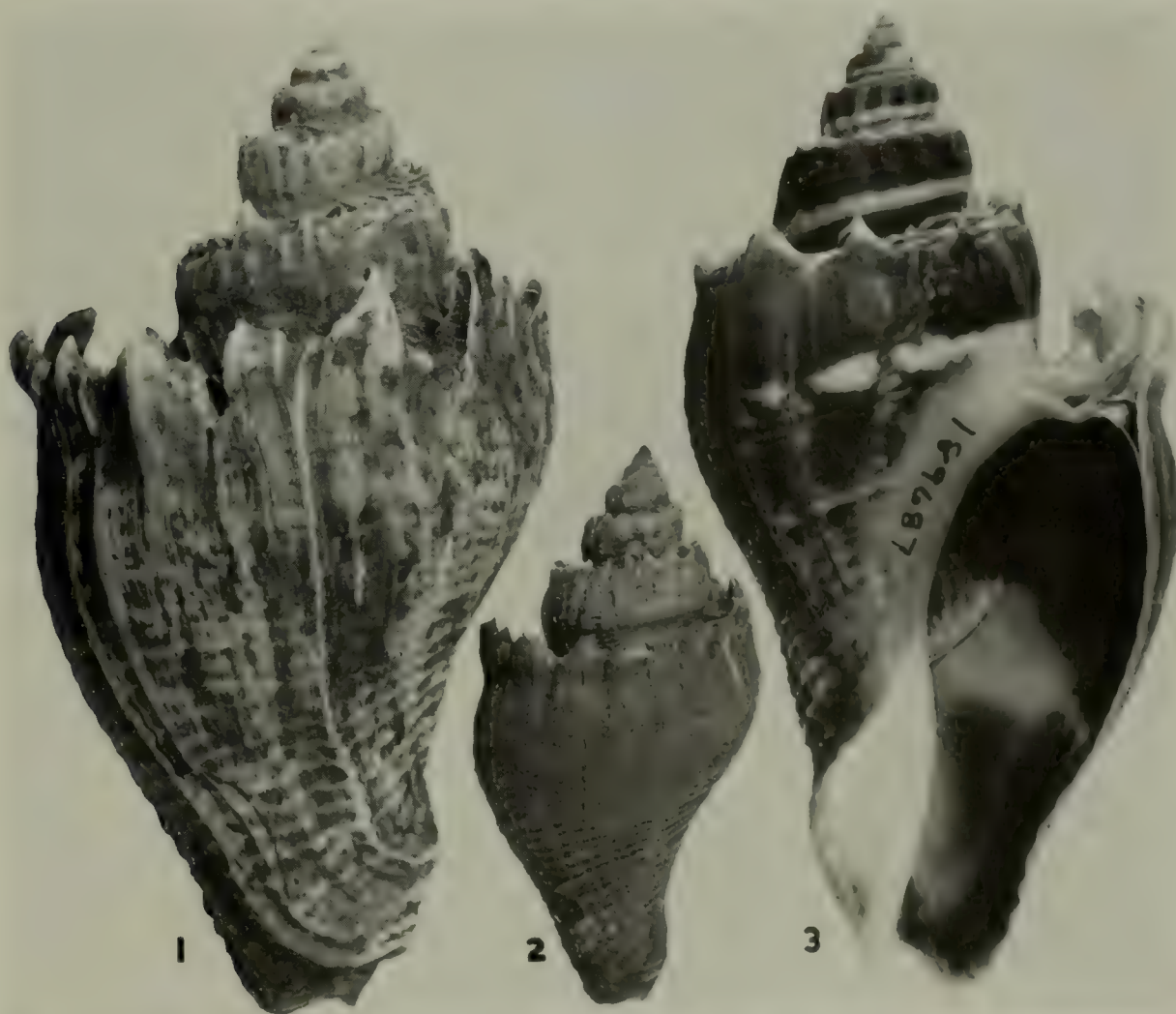


Plate 105. *Melongena corona johnstonei* Clench and Turner. Fig. 1. Holotype. Figs. 2-3. Paratypes, all Little Lagoon, Gulf Shores, Alabama (all natural size).

are obtained at stations both north and west, the specimens become somewhat larger and definitely more attenuate, reaching their ultimate size and attenuation at Gulf Shores, Alabama. The scant data available indicate that if *M. corona* occupied this territory during the warm Pliocene, it was killed out during the cold Pleistocene and invaded this territory anew after the Pleistocene. The subspecies *johnstonei*, having a more uniform gene complex has become somewhat stabilized in the area north of Cedar Keys where it is more or less isolated from the typical *M. c. corona*. This is a result of the small tidal flow in the vicinity of Cedar Keys so that there has been far less opportunity for variable genetic elements of the *corona* complex of the south to reach this area by mechanical means.

See also the remarks under both *M. c. altispira* and *M. bispinosa*.

It is with pleasure that we name this subspecies for Mr. Harry I. Johnstone of Mobile, Alabama.

*Range.* From Gulf Shores, Alabama east to Panacea, Wakulla County, Florida.

*Specimens examined.* ALABAMA: Little Lagoon, Gulf Shores (Mr. and Mrs. H. I. Johnstone; MCZ). FLORIDA: Pensacola (MCZ; T. Pulley); west end of Santa Rosa Island (Univ. of Florida; J. Weber); Fort Walton, Santa Rosa Island (H. I. Johnstone); Port St. Joe (R. Merrill; D. and N. Schmidt; Univ. of Florida); James Island, Franklin Co. (T. Pulley); Panacea (MCZ).

### *Melongena bispinosa* Philippi

Plate 106

*Pyrula bispinosa* Philippi 1844, *Abbildungen und Beschreibungen Conchylien* 1, *Pyrula*, p. 2, pl. 1, figs. 7-8 (locality unknown).

*Pyrula martiniana* 'Pfeiffer' Philippi 1844, *Abbildungen und Beschreibungen Conchylien* 1, *Pyrula*, p. 2, pl. 1, fig. 9 (locality unknown).

*Melongena bispinosa* Philippi, Petit de la Saussaye 1852, *Journal de Conchyliologie* 3, p. 157, pl. 8, fig. 3.

*Melongena corona bispinosa* Philippi, Pilsbry 1934, *Nautilus* 47, p. 120.

*Description.* Shell reaching 75 mm. (about 3 inches) in length, rather light in structure and sculptured. Color light brownish-yellow with one to three spiral bands of dark brown; interior of aperture light yellow. Whorls 6 to 7 and shouldered. Spire somewhat extended; aperture subovate; outer lip rather thin and crenulated. Inner lip usually consisting of a fairly thick callus on the parietal wall. Columella rather broad and flatly sigmoid in profile. Umbilicus usually closed, occasionally with a small perforation. Suture well defined. Sculpture consisting usually of one to three rows of spines at the whorl shoulder; in addition, there is a single row of scale-like spines midway between the periphery and the base of the shell. At the base there are a series of scales which represent former margins of the siphonal canal. A similar series of small scales exists at the suture, which are previous margins of the anal canal. There are numerous thread-like spiral ridges. Axial costae rather strongly developed on the early whorls. These costae are somewhat nodulose.

length	width	
75 mm.	50.0 mm.	from Petit de la Saussaye
43	26.5	Dzilam, Yucatan, Mexico
42	24.5	" " "

*Types.* The whereabouts of the types of both *Melongena bispinosa* and *M. martiniana* Philippi is unknown. They are not in the British Museum (Natural History), where some of Philippi's shells are located, according to Mr. Guy Wilkins who kindly checked this for us.

*Remarks.* This species appears to be nearest in relationship to certain forms of *M. c. altispira* of the Florida east coast. It differs from all other members of the *corona* complex by possessing scale-like spines behind the siphonal canal. These are actually previous margins of this canal. When the animal enlarges the shell it builds a completely new margin to the canal and thus the older ones that are left behind project outwardly, giving the appearance of scales. This same morphological structure is of frequent occurrence in *Murex* and *Rapana*.

The occurrence of this species in Yucatan is one of those anomalous problems in distribution that are exceedingly difficult to explain. This species is completely isolated from other members of the *corona* complex and even in Yucatan occupies only a small area so far as is now known.

It was originally described without any known locality and later Petit de la Saussaye described and figured a specimen which he received from Largilliert, also without locality. Largilliert had collected rather extensively in Central America, including Yucatan, about 1842.

In 1890, Angelo Heilprin, a member of the staff of the Academy of Natural Sciences in Philadelphia, made an expedition to Yucatan mainly in quest of fossil material. Recent marine shells were also collected and these were published by F. C. Baker (1891). Heilprin collected *M. bispinosa* at two stations, Progreso and Silam [Dzilam de Bravo], both on the northern coast of the peninsula. We have seen an additional lot labeled only Yucatan. Undoubtedly more collecting may extend the known range of this species.

Perhaps *M. bispinosa* is only a remnant from the Pliocene of a once far more widely distributed element of the *corona* complex. During this warm period in the geologic past this species complex may have occupied the entire Gulf coast area and later, during the cold Pleistocene these forms may have been driven south or were killed out in the northern portion of the Gulf region. By this means, *M. bispinosa* remains as a relict species, completely isolated from other elements to which it is obviously closely related.

See also remarks under *M. corona johnstonei*.



Plate 106. *Melongena bispinosa* Philippi. Figs. 1-2. Yucatan (natural size).

*Range.* Coast of Yucatan from Campeche (N. E. Weisbord, 1926) to Dzilam de Bravo.

*Specimens examined.* MEXICO: Dzilam de Bravo and Progreso, Yucatan (both ANSP).

### **Melongena bicolor Say**

Plates 96; 107-108

*Fusus bicolor* Say 1827, Journal Academy Natural Sciences, Philadelphia 5, p. 215 (southern coast of East Florida).

*Hemifusus corona minor* Sowerby 1878 [1879], Proc. Zoological Society London, pp. 796, 798 (plate caption), plate 48, fig. 13 (Key West, Florida).

*Hemifusus corona estephomenos* Melville 1881, Journal of Conchology 3, p. 157 (Key West, Florida).

*Description.* Shell reaching 50 mm. (about 2 inches) in length, thin but strong and sculptured with spines. Color a light ivory to pinkish-ivory with spiral bands of brown. These bands are variable but generally there are three, one at the whorl shoulder, one at the periphery of the whorl and a third at the base of the whorl. Early whorls often a uniform dark brown. There are occasional specimens without bands. Whorls 8, moderately convex and with a narrow shoulder. Spire elevated. Aperture subovate. Outer lip thin and very finely crenulated. Inner lip consisting of a very thin glaze. Columella broad and twisted. Umbilicus glazed over by the parietal shield. Sculpture somewhat variable. On the whorl shoulder there may be a single row or rarely two rows of rather small and close-set spines which are erect. Very rarely a basal row of spines is present. In addition to the spines, there are numerous very fine spiral ridges which are a little stronger near the base of the whorl. Axial costae strong and well developed on the early whorls, sometimes persisting even on the body whorl. Sutural imbrications very small and only weakly developed. Operculum as in *M. corona*. Periostracum very thin and a dull brownish in color.

length	height	whorls	
49.0 mm.	25.0 mm.	8	Key Vaca, Florida
43.5	23.0	7	" " "
43.0	22.5	8	Tortugas, Florida

*Types.* The holotype of *Melongena bicolor* Say is in the Academy of Natural Sciences, Philadelphia, no. 34276, from the southern coast of east Florida, Mr. Elliott collector. The types of *M. c. minor* Sowerby and *M. c. estephomenos* Melvill, both names based upon the same specimens, are probably in the British Museum. The type locality is Key West, Florida. This last can also be accepted as the type locality for *bicolor* Say.

*Remarks.* This is quite a distinct species. In relationship it appears to be nearest to *M. c. altispira* Pilsbry and Vanatta but differs by being smaller, much lighter in color and having more and better developed shoulder spines. We have seen no hybrid specimens even where their ranges overlap or approximate one another in the vicinity of Biscayne Bay. In addition, the ecology of the two forms is quite different, *M. bicolor* living usually on the outer sandy beaches where completely marine conditions exist, while *M. c. altispira* is found in brackish water areas. Young specimens of the two species may be difficult to differentiate.

This species is remarkably uniform in size, specimens from several localities showing but little variation. The number of spines on the body whorl, though variable, appears

to be far more constant than is the case in *M. corona*. There is no question but that Say's name *bicolor* applies to this species. His description was based upon very young and worn specimens, but none the less, it agrees entirely with the young of the form that occurs on the Lower Florida Keys (Plate 108, figs. 1-2). Say's type locality "Southern coast of East Florida" could certainly apply to the Florida Keys, and may possibly have been Key West.

Our northernmost record is Biscayne Bay and from here the records extend down the Keys generally on the outer sandy beaches to as far as the Dry Tortugas.

Mr. John H. Butler has kindly contributed the following data on certain of their habits. "These *Melongena bicolor* are to be found only on the Atlantic side of the Florida Keys. They have developed a method of protection from the elements which shields them from hot sun or wave action during storms. They bury themselves in the marly sand and take their food along with them. As the tide comes in they emerge when covered with a few inches of water, then they hunt their meal. They gather two or three *Cerithium*, carry these around until they decide it's time to dig down again, then they go completely out of sight, sometimes as much as four inches down. There they leisurely devour their lunch and wait for the tide to come back again. They do not seem to like brackish water, for they will not come out on a rainy day. Caught out in a summer shower they at once dig down, and most of them will stay down until the tide turns again.

"I have found no live specimens on the Gulf side of the Keys; a few dead shells occasionally, more often than not inhabited by hermit crabs. Scattered specimens may be found in some of the harbors and back bays of the Atlantic side, such as Boot Key Harbor off Key Vaca. These have most likely been washed in by a storm for they do not thrive in such locations. They seem to prefer the open Atlantic shores where the sand is



Plate 107. *Melongena bicolor* Say. Figs. 1-4. Outer beach, Grassy Key, Lower Keys, Florida. Figs. 5-7. Lower Matecumbe Key, Lower Keys, Florida (all 1.2x).

heavy with a high marl content. They are entirely absent from such Keys as Bahia Honda having a fine clean sand beach. Such sand moves readily in a storm and they would be washed up on the beach and exterminated. They seem to be strictly carnivorous, preferring their food fresh and alive. I have never found them feeding on dead fish or dead crabs, unlike the large *Melongena corona* of the west Florida Coast. They are absent from large areas where there are no *Cerithium*, other conditions apparently favorable. Where *Cerithium* are scarce you will find adults only, no juveniles."

*Range.* From Biscayne Bay southwest along the Keys to Dry Tortugas.

*Specimens examined.* FLORIDA: near Coral Gables Canal, Biscayne Bay (D. Moore); Plantation Key (D. and N. Schmidt; H. Moore); Windleys Key (D. and N. Schmidt); Upper Matecumbe Key (MCZ); Lower Matecumbe Key (Carnegie Mus.; MCZ; J. Weber); Upper Grassy Key (D. and N. Schmidt); Grassy Key (J. Butler; R. Cahoon; D. and N. Schmidt); Crawl Key (D. and N. Schmidt); Key Vaca (J. Butler; D. and N. Schmidt); Bahia Honda Key (R. Merrill); Torch Key (MCZ); Sugar Loaf Key (MCZ; Carnegie Mus.; D. and N. Schmidt); Boca Chica Key (Charleston Mus.); Stock Island (Carnegie Mus.); Key West; Dry Tortugas (both MCZ).



Plate 108. *Melongena bicolor* Say. Fig. 1. Lectotype, *Fusus bicolor* Say (= *Melongena bicolor* Say), southern Florida. Fig. 2. Key Vaca, Florida (young) (both about 5.2x).

### Genus *Pugilina* Schumacher

*Pugilina* Schumacher 1817, Essai d'un Nouveau Système des Habitations des Vers Testacés, p. 216.

Type species, *Pugilina fasciata* Schumacher (= *Murex morio* Linné), monotypic.

Shell subdepressed to attenuate, generally rather heavy in structure and relatively smooth to strongly nodulose. Periostracum dark brown and relatively thick. Spiral sculpture variable, consisting of numerous threads or incised lines.

Subgenus **Pugilina** *Schumacher*

Shell subdepressed to extended, rather solidly constructed, smooth to strongly nodulose and having relatively weak spiral threads.

**Pugilina morio** *Linné*

Plates 96 and 109

*Murex morio* Linné 1758, *Systema Naturae*, ed. 10, p. 753 (locality unknown); *ibid.* ed. 12, 1767, p. 1221 (M. Africano); Hanley 1855, *Ipsa Linnaei Conchylia*, p. 300.

*Fusus morio* Linné, Röding 1798, *Museum Boltenianum*, p. 120.

*Fusus coronatus* Lamarek 1803, *Annales du Muséum d'Histoire Naturelle*, Paris 2, pt. 2, p. 321 (no locality given); Lamarek 1816, *Encyclopédie Méthodique*, *Tableau Mollusques et Polypes Divers*, p. 7, *Explanation of pl. 430, fig. 5* [error for fig. 4]; Deshayes 1832, *ibid.*, Vers 2, pt. 2, p. 156 (Sénégal and the Antilles).

*Pugilina fasciata* Schumacher 1817, *Essai d'un Nouveau Système des Habitations des Vers Testacés*, p. 216.

*Pyrula morio* Linné, Reeve 1847, *Conchologia Iconica* 4, *Pyrula*, plate 1, fig. 3.

*Melongena morio* Linné, Tryon 1881, *Manual of Conchology* (1) 3, p. 111, pl. 43, figs. 228-229.

*Semifusus morio* Linné, Dautzenberg 1910, *Actes Société Linnéenne de Bordeaux* 64, p. 204 (p. 48 of the reprint).

*Melongena (Pugilina) morio* Linné, Dautzenberg 1921, *Revue Zoologique Africaine* 9, p. 112.

**Description.** Shell reaching 166 mm. (about  $6\frac{1}{2}$  inches) in length, solid and usually bluntly spinose. Color a dark chocolate brown, with usually one or more narrow bands of light yellowish-brown at the periphery. Whorls 9 to 10 and moderately convex. Spire extended and cast at an angle of about  $55^\circ$ . Aperture narrow, subquadrate and lengthened below into a somewhat broadened siphonal canal. Anal notch small but well developed. Parietal wall heavily glazed, usually chocolate brown in color; occasionally it becomes somewhat lighter in color on the lower columellar area. Outer lip thin but strong and usually finely crenulated. Columella heavy, fairly broad and twisted. Umbilicus completely closed. Suture slightly impressed. Sculpture consisting of several blunt spines which margin the outer edge of the shoulder. Young specimens and the early whorls of old specimens are axially costate. Occasionally the blunt spines are absent or greatly reduced on adult specimens. Spiral sculpture consisting of numerous and fine ridges which are quite apparent on the early whorls but later become somewhat flattened and inconspicuous on the body whorl. In addition, there are several well-marked spiral ridges on the inner wall of the outer lip. Operculum unguiculate with an apical nucleus and with fine concentric ridges. Periostracum dull, dark brown in color, thick, somewhat deciduous and marked with fine axial growth lines. It is thick enough to hide all color of the shell.

length	width	
166 mm.	80 mm.	Banana, Belgian Congo
158 *	94	Carenage, Trinidad, Lesser Antilles
113	59	Trinidad

\* Spire broken

**Types.** According to Hanley 1855, p. 300, the type specimen is in the Linnean Collection. Linné referred to Bonanni 1684, *Recreatio*, Rome, plate 357. In the twelfth edition of the *Systema Naturae*, Linné referred to Adanson 1757, *Histoire Naturelle du Sénégal*, pl. 9, fig. 31. Adanson recorded his species as coming from Gorée Island, Sénégal which is here selected as the type locality.

*Remarks.* This species has been placed in many different genera since it was originally described by Linné. We give in our synonymy most of the important name combinations that have appeared.

The typical form of this species as originally described by Linné was without spines. Later, Lamarck introduced the name *coronatus* for the spinose form. However, there is a complete intergradation between these two forms, with specimens of both occurring in the same locality. Both the spinose and the smooth forms are found in the Western as well as the Eastern Atlantic. This is another of several species that occur on both sides of the Atlantic in the tropics.

*Range.* EASTERN ATLANTIC: According to Nicklès 1950, p. 101, this species ranges from Cap Blanc, French West Africa, south to Angola, Africa.

WESTERN ATLANTIC: Trinidad and south to Ilha do Mel, Est. do Paraná, Brasil (Lange de Morretes 1949, p. 98).

*Specimens examined.* EASTERN ATLANTIC: SIERRA LEONE: Turtle Island, off Sherbo Island; Tasso Island, Rokelle Estuary (both T. S. Jones). LIBERIA: Marshall (MCZ). GOLD COAST: Accra (MCZ). CAMEROONS: Longji (MCZ); Batanga (Carnegie Mus.). RIO MUNI: Benito; Corisco Island (both MCZ; Carnegie Mus.). BELGIAN CONGO: Banana (MCZ).

WESTERN ATLANTIC: LESSER ANTILLES: Tobago (R. W. Cabot); Balandra, Carenage and Salena Bay, Trinidad (all H. G. Kugler). DUTCH GUIANA: Nickerie (D. C. Geijskes). BRASIL: Salinas, Pará (MCZ); Bragança, Pará (Carnegie Mus.); Recife, Pernambuco (MCZ; Carnegie Mus.); Bahia, Bahia (Carnegie Mus.); Ilha de Itaparica, Bahia (M. J. Oliveira); Vitória, Espírito Santo (MCZ).

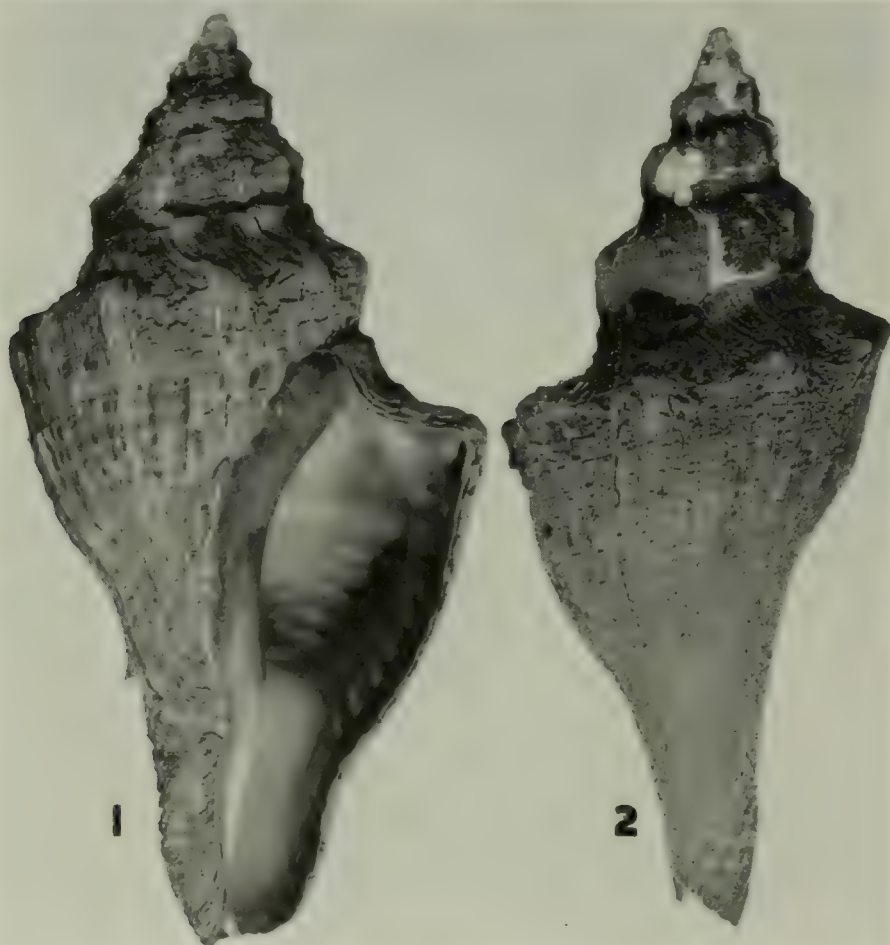


Plate 109. *Pugilina morio* Linné. Figs. 1-2. Vitória, Brasil (about 3/4 natural size).

The following subgenus, *Hemifusus* Swainson, is included only to complete the genus. No species in this subgenus occurs in the Western Atlantic.

### Subgenus *Hemifusus* Swainson

*Hemifusus* Swainson 1840, A Treatise on Malacology, London, p. 308 (and 91).

*Semifusus* Agassiz 1846, Nomenclator Zoologicus, Index, p. 338 [emendation for *Hemifusus* Swainson].

Type species, *Fusus colosseus* Lamarck, subsequent designation, Gray 1847.

Shell attenuate, relatively thin, having generally strong shoulder nodules and possessing a relatively strong sculpture of spiral ridges or threads.

\* \* \* \*

### Notes

*Pyrula melongena mutica* Sowerby 1825, Catalogue of the Shells in the collection of the Earl of Tankerville, London, p. 62 [*nomen nudum*].

*Fusus pyruloides* DeKay 1843, Natural History of New York, Mollusca, Albany, New York, p. 147, pl. 9, fig. 191 (Ship's bottom, New York Harbor, believed to have come from a southern port).

We believe this to be a young *Thais*, perhaps *T. haemastoma* Linné and not a *Melongena* as stated by Tryon (1881, Manual of Conchology (1), 3, p. 229).

\* \* \* \*

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\* \* \* \*

## ADDITIONS TO THE PHOLADIDAE — PART II

BY  
RUTH D. TURNER

The following additions and corrections to the monograph of the Pholadidae seemed of sufficient importance to publish at this time rather than wait until the Review Number which will come at the close of Volume 3.

### Genus *Lignopholas* Turner

Johnsonia **3**, no. 34, p. 98.

Through an unfortunate omission the citation of a type species for this genus was not included in the original description. It is *Lignopholas clappi* Turner.

### *Jouannetia* (Pholadopsis) *quillingi* Turner

Johnsonia **3**, no. 34, pp. 139-140.

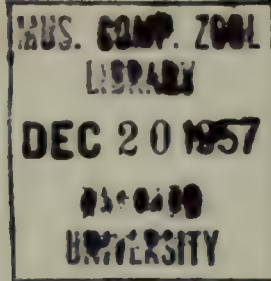
Since the publication of Johnsonia, no. 34, two additional records for this species have been received. These extend the range of the species from off Naples, Florida to off Port Isabel, Texas. Both lots were obtained by shrimp boats. One dead specimen was found in the mud, while the others were taken from soft rock brought up by the dredge.

*Specimens examined:* TEXAS: 40 miles north of Port Isabel in 11-14 fathoms (T. Pulley); East-southeast of Port Isabel in 19-20 fathoms (H. Lee).

# JOHNSONIA

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CYMATIIDAE

VOL. 3, NO. 36

## THE FAMILY CYMATIIDAE IN THE WESTERN ATLANTIC

BY

WILLIAM J. CLENCH AND RUTH D. TURNER

Most species in the family Cymatiidae are referred to as triton shells. They are wide-ranging in all tropical seas, a limited few reaching temperate waters. The family contains more than 100 species, though only a few of these occur in the Western Atlantic. Most of our Western Atlantic species are identical with species occurring in the Eastern Atlantic and Indo-Pacific provinces. No other family so far studied in this series of monographs has had so many species which are so widely distributed. Probably all have a fairly long veliger or free-swimming stage. This has, of course, aided these animals in their dispersal; but it is not the whole answer as many other mollusks with equally long pelagic life have failed to become as widely distributed.

The fossil record indicates that the family was established in the early Tertiary, so that there has been a time factor of considerable importance. The family probably had its origin in the Indo-Pacific, and during the existence of the Tethys Sea several species were able to migrate into the Atlantic Ocean. It would also appear that many specific elements in this family became stabilized fairly early and have since maintained themselves

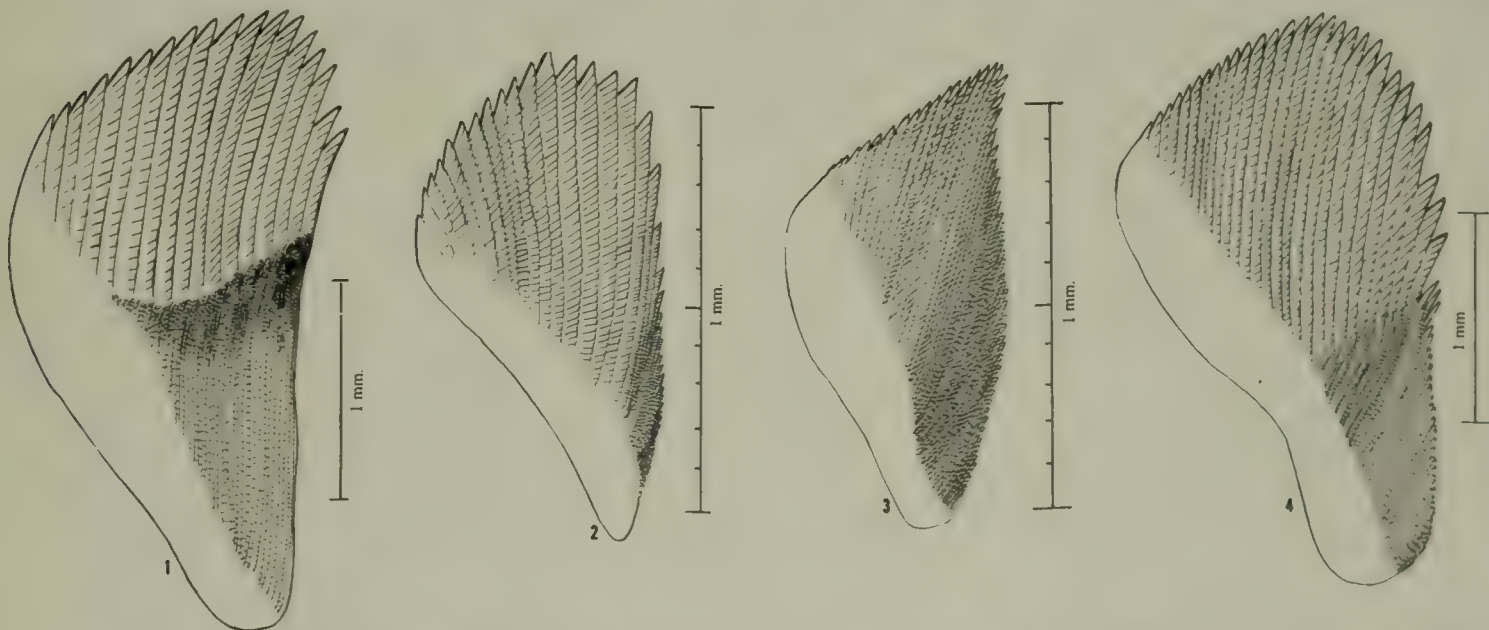


Plate 110. Jaws. Fig. 1. *Cymatium femorale* Linné. Oranjestad, Aruba, Dutch West Indies. Fig. 2. *Cymatium gemmatum* Reeve. Off Palm Beach, Florida. Fig. 3. *Cymatium rubeculum occidentale* Clench and Turner. Carboneras, Río Camarioca, Matanzas, Cuba. Fig. 4. *Cymatium parthenopeum* von Salis. Rio de Janeiro, Brasil.

with but little change in the morphology of the shell. This is not without precedent in other families, such as the Tonnidae, with *Tonna galea* Linné occurring as it does in the Eastern and Western Atlantic and in the Indo-Pacific. Examples of this sort are, however, rare and the present family is quite an exception.

The embryonic shell of all species contained in this family is very different from the adult shell. The embryonic shell is smooth or only feebly sculptured; it is amber or brownish in color and the whorls are only slightly convex. The change from this embryonic state into the young adult is exceedingly abrupt. Strongly marked sculpture appears in the form of ridges which are both spiral and axial, and knobs develop where these ridges cross. The larval or veliger stage may be long, lasting perhaps up to four weeks, so that dispersal by oceanic currents may play a very important part in their distribution. The veliger larvae of *Cymatium pileare* Linné and *C. chlorostomum* Lamarck (= *C. nicobaricum* Röding) have been figured by M. Lebour (1945, pp. 476-477). The four velar lobes are amazingly long and narrow, being about four times the length of the shell.

The feeding habits of most species are completely unknown; probably all are predatory, feeding mainly on other mollusks. The senior author found *Cymatium femorale* Linné feeding on *Laevicardium laevigatum* Linné at Savannah Sound, Eleuthera Island, Bahama Islands.

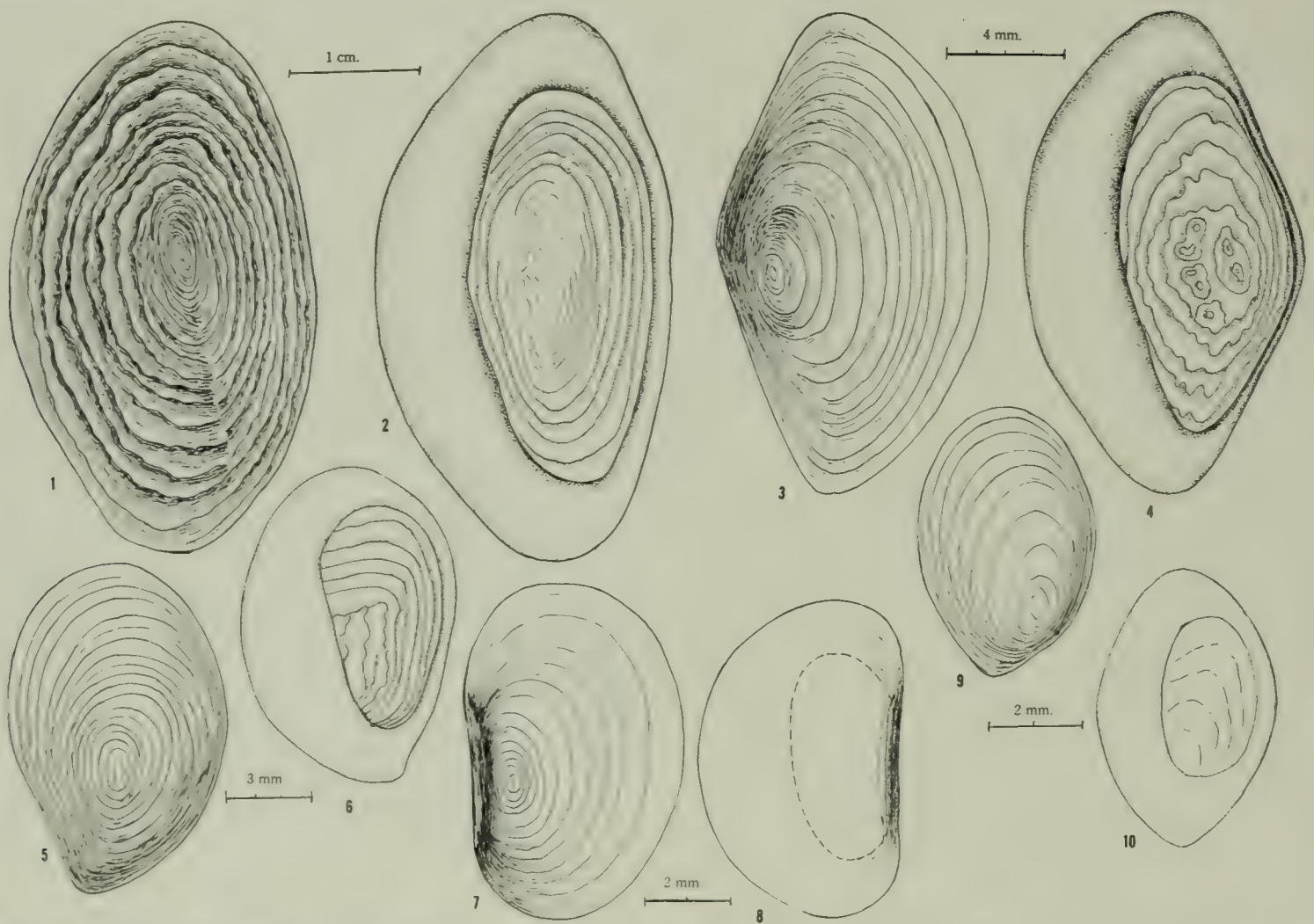


Plate 111. Opercula. Figs. 1-2. *Charonia variegata* Lamarck. Molasses Reef, Key Largo, Florida. Figs. 3-4. *Cymatium caribbaeum* Clench and Turner. Bear Cut, Miami, Florida. Figs. 5-6. *Cymatium nicobaricum* Röding. Molasses Reef, Key Largo, Florida. Figs. 7-8. *Cymatium poulsenii* Mörch. (Young specimen). Off Tampico, Mexico. Figs. 9-10. *Cymatium labiosum* Wood. From an ocean buoy off Cape Romain, South Carolina.

The jaws consist of two subtriangular and very thin chitinous plates which have numerous longitudinal rows of scales. On the basis of the differences shown in the few jaws that we have been able to examine, these may prove to have as much taxonomic value as the opercula. The jaws are lateral and appear to be structures which aid in opening the proboscis during feeding. They do not seem to be strong enough to be used as rasping or grasping organs. The radula, however, is fairly large and strong.

There is a surprising uniformity in the radulae of the various species in the genus *Cymatium*. It would appear that, regardless of what modifications have taken place in the morphology of the shell, the embryonic whorls and the opercula, the radula has remained relatively unchanged. The radula in the genus *Charonia*, however, is quite distinct from that of *Cymatium* (see Plate 113).

The opercula of the several species considered in *Cymatium* show some important differences. In the species *caribbaeum*, *nicobaricum*, *poulsenii* and *labiosum*, the nucleus is eccentric (Plate 111) while in the remaining species in this genus the nucleus is terminal. The nucleus of the operculum of *Charonia variegata* is almost central.

The position of the nucleus of the operculum appears to us to be an important character in the classification of the several subgenera. This character emphasizes the relationships between species which are sometimes difficult to see when dealing only with the several characters of the shell.

From a review of the literature concerning this family, there appears to be no real agreement among the various authors concerning the limits of the genus *Cymatium* and

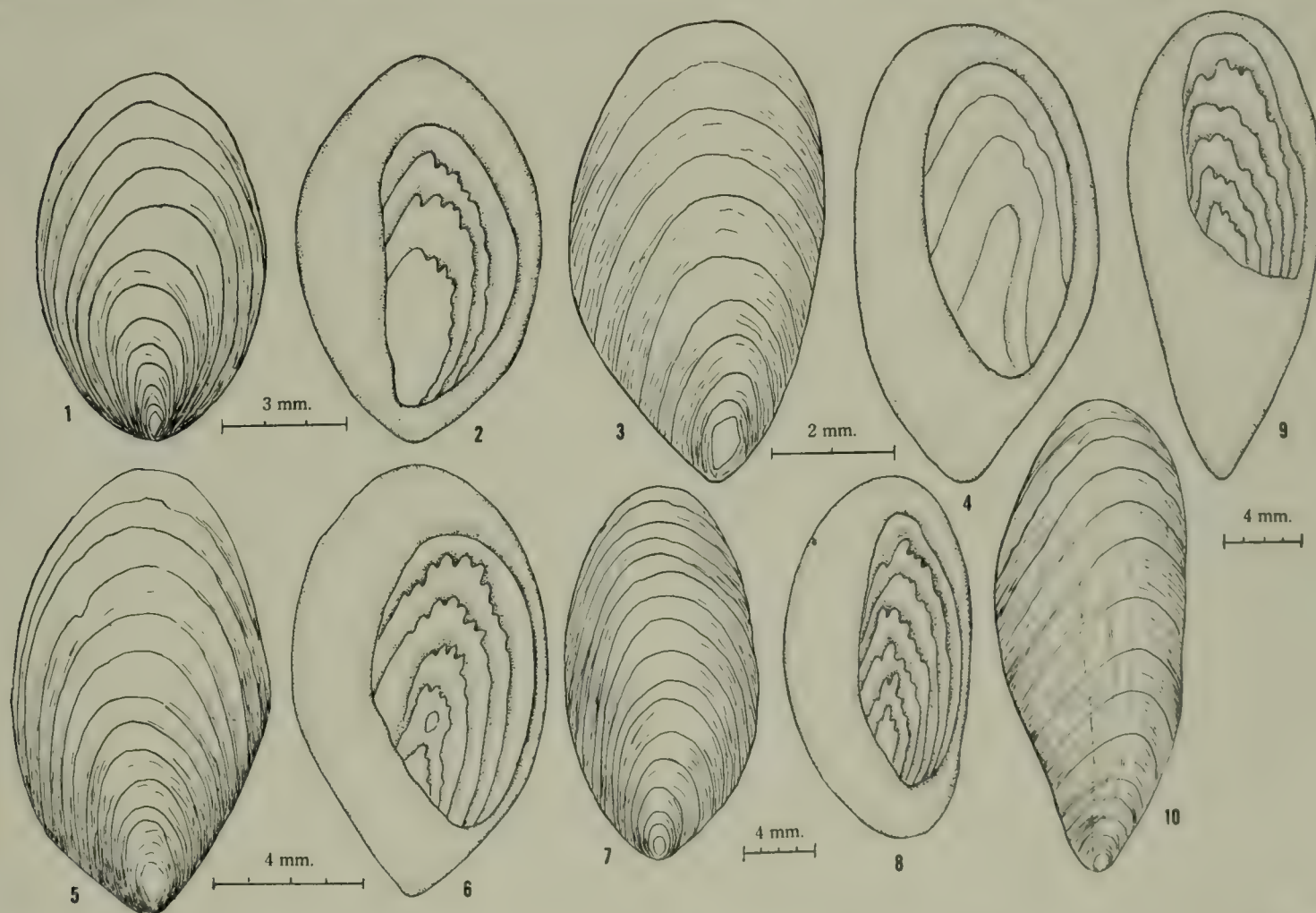


Plate 112. Opercula. Figs. 1-2. *Cymatium pileare* Linné. Varadero Beach, Matanzas Province, Cuba. Figs. 3-4. *Cymatium krebsii* Mörch. Sombrero Key Light, Lower Keys, Florida, in 40 fathoms. Figs. 5-6. *Cymatium muricinum* Röding. Fish Point, Guantánamo, Cuba. Figs. 7-8. *Cymatium parthenopeum* von Salis. Rio de Janeiro, Brasil. Figs. 9-10. *Cymatium femorale* Linné. Bear Cut, Miami, Florida.

its various subgenera. We may be too conservative in considering the various species groups as only subgenera. However, we still lack so much important data regarding these animals, such as their life history, ecology and soft anatomy, that a conservative stand is perhaps best at this time. It must be understood, however, that the various subgenera are not at all of equal value. Relationships between the groups are at different levels. They should be considered convenient categories in our system of classification, subject to change as more data become available.



Plate 113. Radulae. Fig. 1. *Charonia variegata* Lamarck. Jérémie, Haiti. Fig. 2. *Cymatium poulsenii* Mörch. Tampico, Mexico. Fig. 3. *Cymatium coribbaeum* Clench and Turner. Bear Cut, Miami, Florida. Fig. 4. *Cymatium nicobaricum* Röding. Long Reef, off Elliott Key, Florida. Fig. 5. *Cymatium rubeculum occidentale* Clench and Turner. Carboneras, Río Camarioca, Matanzas, Cuba. Fig. 6. *Cymatium gemmatum* Reeve. Off Palm Beach, Florida. Fig. 7. *Cymatium pileare* Linné. Mauritius. Fig. 8. *Cymatium muricinum* Röding. Amboyna Island, Molucca Islands. Fig. 9. *Cymatium parthenopeum* von Salis. Koka Shima, Japan. Fig. 10. *Cymatium parthenopeum* von Salis. Rio de Janeiro, Brasil. Fig. 11. *Cymatium femorale* Linné. Oranjestad, Aruba, Dutch West Indies.

All drawings were made with the aid of a camera lucida at a magnification of 100x and the plate is reduced to about 50x.

#### ACKNOWLEDGEMENTS

The loan of material in *Cymatium* has perhaps been more important to us than in any other group we have considered in Johnsonia. Most species in this group are quite rare and it was only by borrowing material widely that we could obtain an understanding of many of the species. Most of the borrowed material has been recorded under "Specimens examined" and many of the specimens were used in illustrating this paper. A

number of the people listed below also contributed specimens to our collection. We are most grateful to all for their help. Thanks are extended to R. T. Abbott, Academy of Natural Sciences, Philadelphia; C. G. Aguayo, Museo Poey, Universidad de la Habana; E. P. Chace, San Diego Museum of Natural History; R. M. DeWitt, Florida State Museum (referred to in the text as FSM); L. G. Hertlein, California Academy of Sciences; M. Keen, Stanford University; H. de Souza Lopes, Inst. Oswaldo Cruz, Rio de Janeiro, Brasil; H. A. Rehder, United States National Museum; G. L. Voss, Marine Laboratory, University of Miami; G. Warmke, Institute of Marine Biology, University of Puerto Rico. The following private collectors have also been most helpful in loaning material and we wish to thank K. Anderson; M. R. Branham; C. J. Finlay; E. Grigg; K. Johnstone; T. McGinty; R. Merrill; W. Old, Jr.; A. Phares; R. Robertson; J. S. Schwengel; G. Usticke and R. Walker.

### Genus *Charonia* Gistel

*Tritonium* Röding 1798, Museum Boltenianum, p. 125 (type species, *T. tritonis* Linné [= *Murex tritonis* Linné], by tautonymy); non *Tritonium* O. F. Müller 1776.

*Triton* Denys de Montfort 1810, Conchyliologie Systématique 2, p. 587 (type species, *Triton tritonis* Linné [= *Murex tritonis* Linné], original designation), non *Triton* Linné 1758 [Crustacea]; non *Triton* Laurenti 1768 [Reptilia]; non *Triton* Fleming 1828 [= *Tritonalia* Fleming 1828].

*Tritonium* 'Montfort' Bowdich 1822, Elements of Conchology, pt. 1, p. 36 [emendation of *Triton* Denys de Montfort 1810].

*Tritonia* Bowdich 1822, Elements of Conchology, pt. 1, caption of plate 10, fig. 4 [error for *Tritonium* 'Montfort' Bowdich 1822]; non *Tritonia* Cuvier 1798.

*Charonia* Gistel 1848, Naturgeschichte des Thierreichs für höhere Schulen, p. 170, no. 24 [new name for *Tritonium* 'Cuvier' Röding 1798, non Müller 1776].

*Nyctilochus* Gistel 1848, Naturgeschichte des Thierreichs für höhere Schulen, p. xi [new name for *Triton* 'Broderip' Montfort 1810; non Laurenti 1768 (Reptilia)].

*Charonis* 'Gistel' Mörch 1877, Malakozoologische Blätter 24, p. 26 [error for *Charonia* Gistel 1848].

*Buccinatorium* Mörch 1877, Malakozoologische Blätter 24, p. 26 (type species, *Triton nobile* Conrad [= *T. variegatum* Lamarck] here designated).

*Tritonellium* 'Valenciennes' Mörch 1877, Malakozoologische Blätter 24, p. 25; non *Tritonellium* Valenciennes 1858.

*Septa* 'Perry' Dall 1904, Smithsonian Misc. Coll'n. 47, p. 134; non *Septa* Perry 1810 in Arcana.

*Eutritonium* Cossmann 1904, Essais Paléoconchologie Comparée 6, p. 123. [According to J. Thiele 1929. We have not seen this publication.]

*Eutriton* Dautzenberg 1907, Journal de Conchyliologie 55, p. 146 [error for *Eutritonium* Cossmann 1904].

Type species, *Tritonium tritonis* Linné [= *Murex tritonis* Linné] by tautonymy.

Shells medium to very large in size, some specimens reaching about 430 mm. (17 inches) in length, attenuate, imperforate or only minutely rimate and solid in structure. Color of dark browns or reddish-browns, usually in marbled patterns. Sculpture generally consisting of spiral ridges and finer threads, the ridges with or without definite nodules. Varices present, but apparently produced irregularly. Aperture large and usually flaring, with sculpture on both inner and outer lips. Siphonal canal distinct and short.

### *Charonia variegata* Lamarck

Plate 111, figs. 1-2; Plate 113, fig. 1; Plate 114, figs. 1-2

*Tritonium marmoratum* Link 1807, Beschreibung der Naturalien-Sammlung der Universität zu Rostock, p. 122 [in part, Chemnitz' reference only; see *Remarks* below].

*Triton variegatum* Lamarck 1816, Tableau Encyclopédique et Méthodique, Liste, p. 5, Atlas 3, pl. 421, fig. 2a-b (no locality given); Lamarck 1822, Animaux sans Vertèbres 7, p. 178 [in part]; De Blainville 1825, Manuel de Malacologie, p. 399, pl. 18, figs. 3-3a; Kiener 1842, Iconographie des Coquilles Vivantes *Triton*, p. 28, pl. 2.

*Tritonia atlantica* 'Montfort' Bowdich 1822, Elements of Conchology, part 1, plate 10, fig. 4 (no locality given other than that indicated by the name).

*Triton variegatus* var.  $\beta$  Reeve 1844, Conchologia Iconica 2, *Triton*, pl. 1, fig. 3a (West Indies).

*Triton nobilis* Conrad 1848, Proceedings Academy Natural Sciences Philadelphia 4, p. 121 (West Indies); Conrad 1849, Journal Academy Natural Sciences Philadelphia (2) 1, p. 212.

*Triton commutatus* 'Dunker' Kobelt 1876 [in] Martini and Chemnitz, Systematisches Conchylien-Cabinet (2) 3, pt. 2, p. 224 [nomen nudum].

*Tritonium seguenzae* Aradas and Benoit 1871, Atti dell' Accademia Gioenia di Scienze Naturali di Catania (3) 5, p. 90 (Sicily); W. Kobelt 1889, Iconographie Europäischen Meeresconchylien 2, p. 19, pl. 35, fig. 1; pl. 36, fig. 1; pl. 37, fig. 1.

*Description.* Shell large, reaching 331 mm. (about  $13\frac{1}{4}$  inches) in length, attenuate, rather heavy in structure, imperforate or with a narrow rimation. Color of the early whorls salmon-pink changing to a mottled coloration brought about by the alternate chevron-shaped bars of brown and white which follow the spiral cords. Whorls remaining in the adult 11 to 12, convex, the last proportionately larger and generally producing a pronounced sloping shoulder. Spire extended and very acutely pointed, forming an angle of  $33^{\circ}$  to  $43^{\circ}$ . Aperture subcircular to ovate. Outer lip expanded and margined with short plicae that are usually grouped in pairs and are opposite the furrows of the outside sculpture. Between the paired plicae and at the extreme margin of the lip there is usually a small dull point. The plicae are white and the space between and extending to the lip edge is a dark chocolate-brown. The intervals between the paired plicae are a light brownish-ivory in color. Parietal wall with numerous plicae which extend from the margin of the parietal shield well within the whorl. Actually these plicae have had a continuous growth from the very early stages but are absorbed as the animal builds the shell forward. These plicae are irregular as to width and spacing. They are white and the area between them is a dark chocolate-brown. Columella fairly wide and slightly arched. Umbilicus, when present, consisting only of a very narrow rimation beneath the parietal shield. Siphonal canal short and fairly broad. Suture irregular and not indented. Sculpture consisting of numerous flattened spiral ridges, separated by fairly broad furrows, the shoulder ridge being the largest. At the bottom of the furrows there may be from one to three spiral threads. Usually the ridges are narrow and small near the suture and again at the base of the body whorl. At the suture there is a band that is sculptured with short axial threads. Nuclear whorls five, smooth and pink in color but generally covered with a fairly heavy brownish periostracum. First four post-nuclear whorls with a spiral sculpture of nodulose ridges with spiral threads between. These whorls are usually salmon-pink in color. Beyond the fourth post-nuclear whorl the normal adult sculpture begins. The first varix appears at the end of the first post-nuclear whorl and is repeated about every three-fourths of a whorl thereafter. Operculum corneous, elliptical in outline, outer surface with a central nucleus and concentric growth lines. Inner surface with a large muscle scar, sculptured with numerous, fine, raised and irregularly concentric threads which at irregular intervals form little double-looped rings. Area beyond the muscle scar smooth and highly polished.



Plate 114. Fig. 1. *Charonia variegata* Lamarck. Bimini Islands, Bahama Islands (about  $3/5x$ ). Fig. 2. *Charonia variegata* Lamarck. Cuesco Beach, Guantánamo, Cuba (embryonic shell,  $5.6x$ ). Fig. 3. *Charonia tritonis* Linné. Ryukyu Islands, Japan (about  $2/3x$ ).

length	width	
331 mm.	168 mm.	St. Thomas, Virgin Islands
280	145.5	Lectotype of <i>C. nobilis</i> Conrad
255	113	Santa Bárbara de Samaná, Santo Domingo, Hispaniola
238	121	Alice Town, North Bimini, Bimini Islands, Bahama Islands
235	120	Sandy Cay, 4 mi. NW of Hope Town, Great Abaco, Bahama Islands

*Types.* The lectotype of *T. nobilis* Conrad is in the Academy of Natural Sciences Philadelphia, no. 42537 from the West Indies. According to Kiener the type of *T. variegata* Lamarck is in the Paris Museum. We here restrict the type locality to St. Thomas, Virgin Islands.

*Remarks.* This is one of the largest of our Western Atlantic gastropods. Though not rare, it does not seem to be common at any one locality.

It is very close in relationship to *Charonia tritonis* Linné (Plate 114, fig. 3), a wide-ranging species of the Indo-Pacific region but it differs from that species by never attaining the large size of *tritonis*. In addition, *C. variegata* differs by having a fairly well developed shoulder but a narrower and less flaring lip in the adult. The plicae on the outer lip of *tritonis* are proportionately much flatter and in many cases they are absent or are indicated only by the color markings. The plicae on the outer lip of *variegata* are always very well developed and are generally grouped in pairs. The plicae on the parietal wall of *tritonis* are much broader than those of *variegata*, so they limit definitely the amount of brown coloration on the columella.

There has been a great deal of confusion regarding the names to be employed for the Atlantic and Indo-Pacific species in this complex. Most of the early descriptions were composites, and many references by Linné, Gmelin and others were given to either one or the other indiscriminately. In Linné's original description of *tritonis* his citations were to Bonnani, Rumphius and Gualtieri. The first two refer to the Indo-Pacific species, *tritonis*, and the last is to the Atlantic species. We here select the figure in Bonnani 1684, *Recreatio*, fig. 188, to be the type figure of *tritonis* Linné. In 1807, Link (*loc. cit.*) introduced *Tritonium marmoratum* as a substitute name for *Murex tritonis* Linné. Link's first reference was to Gmelin 1791, *Systema Naturae*, ed. 13 and his second was to Chemnitz 1780, *Conchylien-Cabinet*. We here restrict Link's name to Gmelin's reference to Bonnani, *Recreatio*, fig. 188, so that both names (*tritonis* Linné and *marmoratum* Link) are now based upon the same figure.

So far as we have been able to determine, the earliest valid name for the Western Atlantic species is *Triton variegatum* Lamarck. This species has usually been dated from Lamarck's description in the *Animaux sans Vertèbres* 1822. However, Lamarck originally named this species in the *Tableau Encyclopédique et Méthodique* in 1816, referring to the figure in the *Atlas*. This figure is very definitely of the Atlantic species. Later, in 1822, as stated above, Lamarck described this species and gave several references which included both the Indo-Pacific and the Atlantic forms. Because of this later description, Lamarck's *variegata* has been considered a synonym of *C. tritonis* Linné, as his earlier use of the name in 1816 had been completely overlooked.

This species is generally found about rocky reefs below low water. Specimens taken from fish traps that had been placed in 60 to 120 fathoms are very much lighter in structure and somewhat smoother. Mr. C. J. Finlay reports that these specimens were not alive but were inhabited by hermit crabs.

*Range.* EASTERN ATLANTIC: Mediterranean Sea, Cape Verde Islands, the Canary Islands and St. Helena. WESTERN ATLANTIC: Bermuda (A. J. Peile), the Bahama Islands, the Lower Florida Keys, the West Indies and from central Mexico south to Santos, Estado São Paulo, Brasil.

*Specimens examined.* WESTERN ATLANTIC. FLORIDA: Molasses Reef, Key Largo (MCZ; R. Work); Key West (ANSP); Tortugas (MCZ). BERMUDA: Castle Harbour (H. B. Moore—dredged and dead). BAHAMA ISLANDS: Elbow Cay; Sandy Cay, 4 miles NW of Hope Town, both Great Abaco (both R. Robertson); Alice Town, North Bimini Island, Bimini Islands (MCZ); Pigeon Cays, Andros (J. Schwengel); Bullocks Harbour, Great Harbour Cay, Berry Islands; Dicks Point, Nassau, New Providence; The Current, Eleuthera Island (all G. Kline); Spanish Wells, northern Eleuthera (J. Schwengel); Governors Harbour, Eleuthera; Little San Salvador Island; Arthurs Town, Cat Island (all MCZ); Channel Cay, Great Exuma Island (G. Kline); Clarence Town, Long Island; Abraham's Bay, Mariguana Island; Matthew Town, Great Inagua (all MCZ). CUBA: Cabanas Bay, Pinar del Río (USNM); Matanzas Bay, Matanzas in 90–120 fathoms (C. J. Finlay); Cayo Francés, Caibarién, Las Villas (P. Bermudez); Cayo Largo, Banco de los Jardines, Las Villas (ANSP); Cayo Maja Figuro, off Punta Alegre, Camagüey (R. Humes); off Gibara, Oriente in 60–80 fathoms (C. J. Finlay); Cuesco Beach, Guantánamo Naval Base, Oriente (MCZ). HISPANIOLA: Monte Cristi; Blanco, 30 km. NW of Puerto Plata; Puerto Plata; Puerto Sosúa; Santa Bárbara de Samaná, all Santo Domingo (all MCZ); Saltrou, Dept. de l'Ouest; Roche à Bateau, Dept. du Sud; Ile de la Gonave, all Haiti (all USNM); Jérémie, Dept. du Sud, Haiti (MCZ). JAMAICA: St. Anns Bay; near Buff Bay, Portland; Bull Bay, St. Andrews (all USNM). PUERTO RICO: Arecibo (G. Warmke); Mona Island (A. Phares); Rincón Light, Rincón (G. Warmke; MCZ); reef 6 miles off Mayagüez (K. Yates); Mayagüez (G. Warmke); Punta Cuchara, about 5 mi. SW of Ponce (G. Warmke). VIRGIN ISLANDS: St. Thomas (ANSP; USNM); The Baths, Virgin Gorda (M. Dewey). LESSER ANTILLES: St. Kitts (MCZ); Barbados (MCZ; USNM); St. Vincent (USNM); Grenada (K. Anderson); Bucco Reef, Tobago (MCZ; ANSP); Cyril Bay, Trinidad (H. G. Kugler). CARIBBEAN ISLANDS: Swan Island (MCZ); Grand Cayman, Cayman Islands (ANSP). MEXICO: Lobos Island, near Tampico; Tampico, both Tamaulipas (both T. Pulley); Veracruz, Veracruz (M. E. Bourgeois; ANSP); Isla Mujeres, Yucatan (C. G. Aguayo). PANAMA: Colón (MCZ; USNM). COLOMBIA: near Cartagena (USNM). VENEZUELA: Tucacos Bay, Estado Falcón (H. G. Kugler). BRASIL: Santos, Estado São Paulo (ANSP).

EASTERN ATLANTIC. MEDITERRANEAN ISLANDS: Off Old Limassol, Cyprus (J. K. Howard). LEBANON: Beirut (USNM).

### Genus *Cymatium* Röding

*Cymatium* Röding 1798, Museum Boltenianum, p. 129.

*Lotorium* Denys de Montfort 1810, Conchyliologie Systématique 2, p. 583 (type species, *Lotorium lotor* Montfort [= *Murex femorale* Linné] original designation); non *Lotorium* Pusch 1837).

*Currus* Lesson 1842, L'Echo du Monde Savant (2) 6, Col. 65 [reference from Dall 1904, p. 139. We have not seen this publication].

*Luterium* Herrmannsen 1846, Indicis Generum Malacozoorum 1, p. 632. [Emendation of *Lotorium* Denys de Montfort.]

Type species, *Murex femorale* Linné, subsequent designation. Dall 1904.

Shells ranging in size from about 25 mm. (1 inch) to 212 mm. (about 8 inches) in length. Generally brown in color with bands of darker brown or red-brown. Many species show remnants of banding on the varices. Nearly all known species have one to six varices. They are generally sculptured with spiral cords which may or may not be beaded and, in many cases, the cords are knobbed. Siphonal canal generally fairly short and turned upward. Inside of outer lip usually with fine to coarse denticles. Parietal area generally having numerous lamellae. Periostracum generally heavy and produced in axial fringed blades. Operculum subcircular, sculptured with concentric growth lines and with an eccentric or terminal nucleus. Embryonic whorls fairly large, generally persistent and usually smooth or sculptured with microscopic axial striae.

All members of this genus occur only in the tropics or in the warmer portions of the temperate zone. They generally are found from the low water line out to depths of a little over 100 fathoms.

The genus *Cymatium* is composed of a number of subgenera many of which have been raised by various authors to generic rank. However, considering this genus from a world point of view, many of the characters used for separating the groups overlap. Consequently, it is impossible to assign clear cut definitions and it is often difficult to place species in the proper subgenus.

### Subgenus *Linatella* Gray

*Linatella* Gray 1857, Guide to the Systematic Distribution of Mollusca in the British Museum, p. 39.

*Zinatella* Cossmann 1903, Essais de Paléoconchologie Comparée 5, p. 86 [error for *Linatella* Gray].

Type species, *L. cingulata* Lamarck [= *C. cynocephalum* Lamarck] monotypic.

Shell medium to small in size and generally uniformly light yellowish brown in color and, in some, spirally banded with dark brown, particularly on the spiral cords. Sculpture consisting of numerous low and occasionally knobbed spiral cords. Only a few specimens produce more than one lip varix. Siphonal canal short and turned upward. Aperture subcircular. Outer lip with fine to fairly coarse denticles. Parietal area with or without lamellae. Periostracum rather thin, deciduous and produced in numerous low axial blades which are minutely fringed. Operculum subcircular, with an eccentric nucleus and sculptured with concentric growth lines.

### *Cymatium* (*Linatella*) *poulsenii* Mörch

Plate 111, figs. 7-8; Plate 113, fig. 2; Plate 115, figs. 1-3

*Triton* (*Linatella*) *poulsenii* Mörch 1877, Malakozoologische Blätter 24, p. 33 (Curaçao and Porto Cabello [Venezuela]).

*Fusus cutaceus* Lamarck 1816, Tableau Encyclopédique et Méthodique 3, pl. 427, fig. 4 a-b; Liste, p. 6; non *Triton cutaceus* Lamarck<sup>1</sup> 1816, ibid. pl. 414, fig. 2 a-b, Liste, p. 4 which is *Cymatium cutaceum* Linné.

*Cymatium cingulatum peninsulium* M. Smith 1937, East Coast Marine Shells, p. 113 (Lake Worth, Florida).

**Description.** Shell moderate in size, reaching 75 mm. (about 3 inches) in length, rather thin in structure, imperforate or nearly so, and spirally sculptured. Color light straw-

<sup>1</sup> This species has often been credited to Lamarck; but in 1822, Animaux sans Vertèbres 7, p. 188, Lamarck definitely gives credit to Linné and refers to the same figures in Seba. This is a Mediterranean species.

yellow to a medium brown and occasionally banded with darker brown. Specimens occur rarely with axial stripes of darker brown. Post-embryonic whorls four, convex, with the body whorl slightly shouldered. Spire moderately extended and produced at an angle of about  $75^\circ$ . Aperture subelliptical in outline, the outer lip crenulated and slightly expanded. Inner lip with a light glaze on the body whorl and a much heavier glaze over the columella. Siphonal canal variable, moderately long and curved upward. Columella arched inward, its base continuing as the parietal margin of the siphonal canal. Suture slightly indented. Sculpture consisting of 18 to 20 major flattened spiral cords which are somewhat variable in height and width. In some specimens finer spiral cords may be present between the major cords. The shoulder cord of occasional specimens may be slightly beaded. Axial sculpture consisting of fine growth lines, with occasional specimens having a thin blade-like varix. Periostracum thin, usually deciduous and consisting of numerous fine axial blades from which extend short hair-like processes. Operculum thin, corneous, subcircular in outline, with concentric growth lines and an eccentric nucleus. Embryonic whorls 3 to  $3\frac{1}{2}$ , smooth, yellowish horn in color, narrow, extended, and set off from the later whorls.

length	width	
75 mm.	43 mm.	Lake Worth, Florida
65	45.5	off Port Isabel, Texas
58	33.5	off Laguna Madre, Tamaulipas, Mexico

*Types.* The holotype of *T. poulsenii* Mörch is probably in the Universitetets Zoologiske Museum, Copenhagen, Denmark. The location of the holotype of *F. cutaceus* Lamarck is unknown to us. The holotype of *Cymatium cingulatum peninsulium* M. Smith is in the Florida State Museum, Gainesville, Florida.

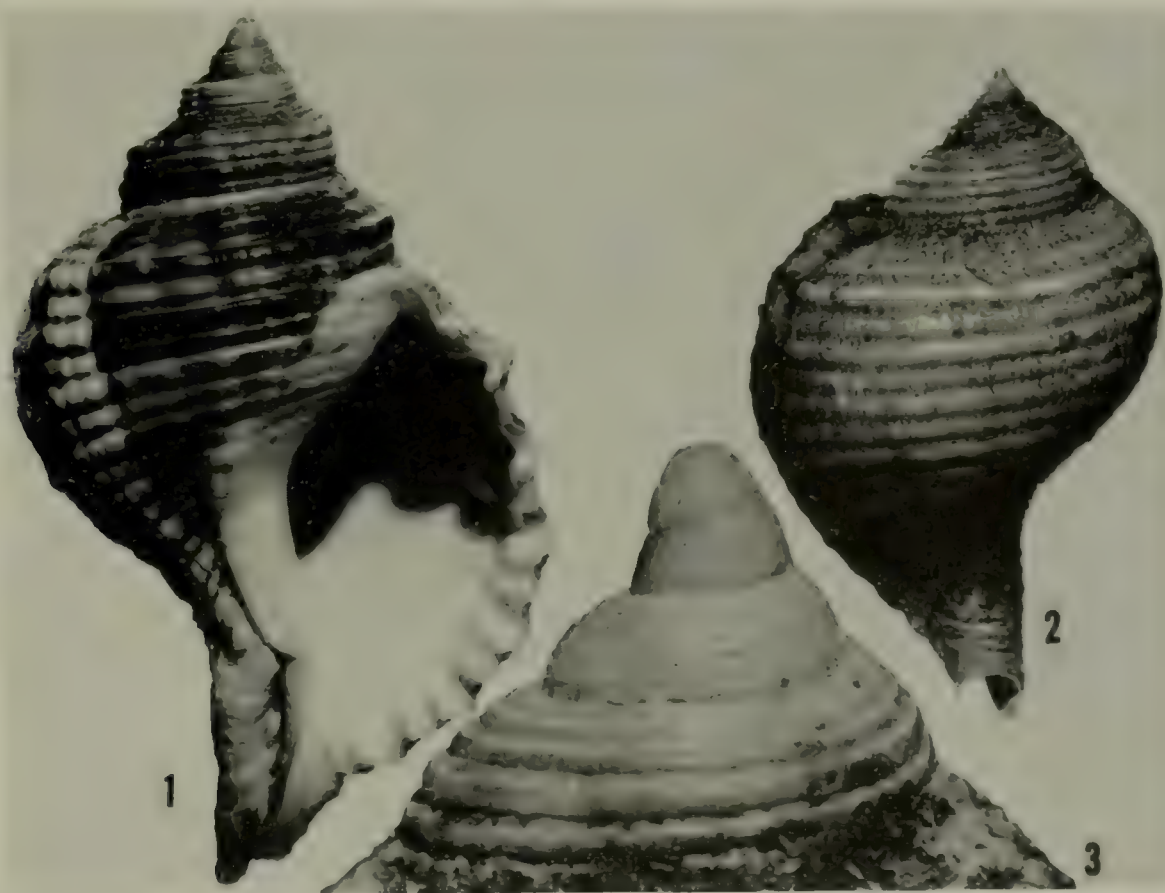


Plate 115. *Cymatium poulsenii* Mörch. Fig. 1. South end of Lake Worth, Palm Beach Co., Florida (slightly enlarged). Fig. 2. Off Laguna Madre, Tamaulipas, Mexico (1.24x). Fig. 3. Off Laguna Madre, Tamaulipas, Mexico (17x).

*Remarks.* This species is among the rarest of our Western Atlantic cymatiids. It has a fairly wide range throughout the Gulf of Mexico and the Caribbean Sea and, so far as now known, it lives well below low water line. Our few depth records range from 12 to 209 fathoms. The specimens from off the Barbados in 209 fathoms were apparently dead when collected and they may be advectitious at this depth.

This species is closely related to *Cymatium cynocephalum* Lamarck<sup>1</sup> from the Eastern Pacific. It differs by being much smaller and in having the spire far less extended.

*Range.* From Lake Worth, Florida south through the West Indies, and from west Florida to Texas, Mexico and south to Venezuela.

*Specimens examined.* FLORIDA: Palm Beach in 14 fathoms (J. Schwengel); Lake Worth (FSM: T. McGinty); Boynton Beach; off Delray Beach (both T. McGinty); Bear Cut, Crandon Park, Biscayne Bay (R. Merrill); Bahia Honda Key; off Key West in 11 fathoms (both H. and K. Johnstone); off Tortugas, from shrimp boat in 18–20 fathoms (R. Merrill; T. McGinty); Naples (ANSP). TEXAS: 30 miles N of Port Isabel (H. Hildebrand); off Port Isabel (W. C. Frisby; H. and K. Johnstone; T. McGinty). MEXICO: off Laguna Madre, Tamaulipas in 12 to 14 fathoms (C. L. Branch); Tampico, Tamaulipas (T. Pulley); about 70 miles NNE of Tampico, Tamaulipas (W. C. Frisby); 15 miles N of Tecolutla, Veracruz (T. Pulley). CUBA: Puerto Esperanza, Pinar del Río (C. G. Aguayo). VIRGIN ISLANDS: St. Thomas (ANSP). LESSER ANTILLES: off Barbados, *Blake* station 274 (N. Lat. 13°00'50''; W. Long. 59°36') in 209 fathoms (MCZ). VENEZUELA: Cubagua Island off Cumaná (MCZ).

### Subgenus *Cabestana* Röding

*Cabestana* Röding 1798, Museum Boltenianum, p. 130.

*Aquillus* Denys de Montfort 1810, Conchyliologie Systématique 2, p. 579 (type species, *Aquillus cutaceus* [= *Murex cutaceus* Linné] original designation).

*Dolarium* Schlueter 1838, Systematisches Verzeichniss meiner Conchyliensammlung, Halle, p. 20 (type species, *Murex caduceus* [error for *cutaceus* Linné], monotypic).

*Aquilus* Mörch 1852, Catalogus Conchyliorum Comes de Yoldi, p. 108 (error for *Aquillus* Montfort).

*Neptunella* Gray 1853 [1854] Proceedings Zoological Society London, p. 38 (type species, *Murex cutaceus* Linné, monotypic); non *Neptunella* Meek 1864; non Verrill 1873.

*Tritonicus* Dall 1904, Smithsonian Miscellaneous Collections 47, p. 134 (type species, *Triton loroisi* Petit de la Saussaye [= *C. labiosum* Wood] original designation).

*Turritriton* Dall 1904, Smithsonian Miscellaneous Collections 47, p. 133 (type species, *Triton gibbosus* Broderip, original designation).

*Particymatium* Iredale 1936, Records Australian Museum 19, p. 307 (type species, *Triton strangei* Adams and Angas, monotypic).

*Cabestanimorpha* Iredale 1936, Records Australian Museum 19, p. 307 (type species, *Triton exaratum* Reeve, monotypic).

*Cymatilesta* Iredale 1936, Records Australian Museum 19, p. 307 (type species, *Triton spengleri* Lamarck, monotypic).

*Particymatium* 'Iredale' Wenz 1941, Handbuch der Paläozoologie 6, pt. 1, p. 1063 [error for *Particymatium* Iredale].

Type species, *Murex cutaceus* Linné, subsequent designation, Dall 1904.

<sup>1</sup> This is an earlier name for *Cymatium cingulatum* Lamarck. See remarks under *C. caribbaeum* Clench and Turner, new name, regarding the use of the name *cynocephalum* Lamarck.

Shells relatively small to medium in size and generally brownish in color. Sculpture consisting of a few varices and rather strongly developed, knobbed, axial costae. Many species in this subgenus have very well developed spiral cords. Whorls with a broad shoulder. Siphonal canal short. Shells usually rimately umbilicate. Periostracum thin. Operculum unguiculate, with a marginal nucleus.

There are two species in this subgenus in the Western Atlantic.

***Cymatium (Cabestana) labiosum* Wood**

Plate 111, figs. 9–10; Plate 116, fig. 1

*Murex labiosus* Wood 1828, Index Testaceologicus, Supplement, p. 15, pl. 5, fig. 18 (locality unknown); non *Murex labiosa* J. E. Gray 1828; non G. D. Nardo 1847.

*Tritonium rutilum* Menke 1843, Molluscorum Novae Hollandiae, p. 25 (litore occidentali [shore of western Australia] ).

*Triton loroisi* Petit de la Saussaye 1852, Journal de Conchyliologie 3, p. 53, pl. 2, fig. 8 (Guadeloupe [Lesser Antilles] ).

*Triton strangei* Adams and Angas, July 1864, Proceedings Zoological Society London, p. 35 (Moreton Bay [Queensland] Australia); Smith 1878 [1879] Proceedings Zoological Society London, p. 816, pl. 50, fig. 16.

*Triton (Gutturium) orientalis* G. and H. Nevill 1874, Journal Asiatic Society Bengal 43, p. 29. Refers to figure in Reeve, Conchologia Iconica 2, Triton, pl. 11, fig. 38 (Andamans, dredged).

**Description.** Shell rather small, reaching 29.5 mm. (about  $1\frac{1}{8}$  inches) in length, solid, minutely perforate, shouldered and strongly sculptured. Color generally mahogany-brown to yellowish and occasionally with a white band at the middle of the whorl. Interior of aperture white. Post-embryonic whorls 5 and strongly convex. Spire moderately extended and produced at an angle of about  $60^{\circ}$ . Aperture subcircular, with the outer lip greatly thickened when a varix is produced. Parietal lip narrow and thickly glazed. Outer lip with 6 flattened and rather obscure denticles. Inner lip with very weak lamellae—usually one near the anal canal and two or three near the entrance of the siphonal

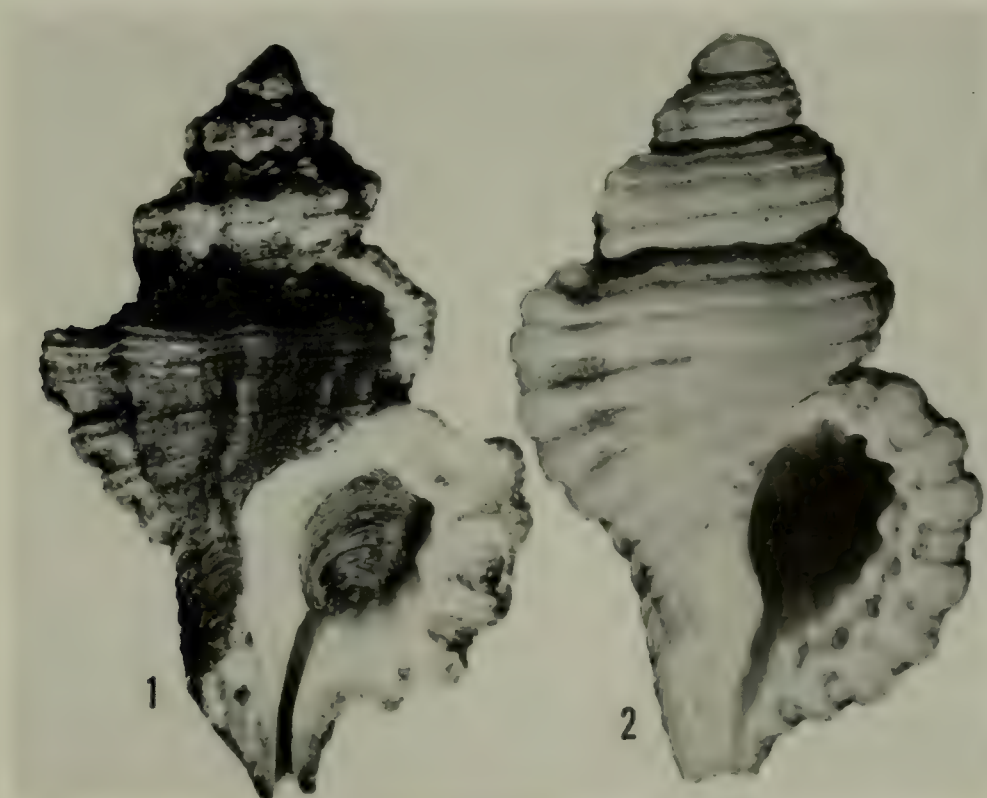


Plate 116. Fig. 1. *Cymatium labiosum* Wood. Carboneras, Río Camarioca, Matanzas, Cuba (2.8x). Fig. 2. *Cymatium felipponei* von Ihering. Praia de Guarariba, Vitoria, Estado Espírito Santo, Brasil (1.85x).

canal. Columella slightly arched inwardly with its base continuing into the parietal margin of the short siphonal canal. Suture slightly indented. Sculpture consisting of 4 to 6 strong, nodulose, spiral cords. In addition, these cords are sculptured with 3 or 4 beaded threads. Beaded threads are also found in the interspaces between the major cords. From each knob on the shoulder cord there is a ridge extending to the suture. This ridge continues axially to the base of the shell. Periostracum straw-yellow in color and consisting of very low thin axial blades. Operculum unguiculate, with a marginal nucleus and sculptured with concentric growth lines. Embryonic whorls  $3\frac{1}{2}$ , moderately convex, amber in color and with very fine axial striae.

length	width	
29.5 mm.	18.5 mm.	North Inlet, Lake Worth, Florida
27	18	Carboneras, near Río Camarioca, Matanzas, Cuba
26.5	16.5	Zanzibar Island
24	15	St. Thomas, Virgin Islands
22.5	15	Funafuti, Ellice Islands

*Types.* The location of the type of *C. labiosum* Wood is unknown. It was originally in the cabinet of a Mrs. John Mawe and according to Sherborn it was purchased by "Tennant of the Strand." As the locality was unknown we here designate Guadeloupe, Lesser Antilles as the type locality. The type of *C. strangei* Adams and Angas was in the Angas Collection and is now probably in the British Museum. An idiosyncrasy from Angas is in the Museum of Comparative Zoology. The type locality is Moreton Bay, Queensland, Australia. The type of *C. loroisi* Petit de la Saussaye is in the collection of the Journal de Conchyliologie: the type locality is Guadeloupe, Lesser Antilles.

*Remarks.* This is a very distinctive species, not closely related to any other in the Western Atlantic. It is nearest in relationship to *C. felipponei* von Ihering from which it differs in being much smaller and having a more pronounced axial sculpture and a pronounced angle to the whorl shoulder. In the Indo-Pacific there appear to be two or three fairly closely related species. *Cymatium waterhousii* Adams and Angas from South Australia has a proportionately much larger aperture and *C. klenei* Sowerby from South Africa is much more strongly shouldered and sculptured, as well as being a larger and more elongate species.

This appears to be a rather rare species and many of the specimens in collections are dead beach shells. Nothing is known concerning depth range or habitat of this species.

*Range.* WESTERN ATLANTIC: From off Cape Romain, South Carolina; Florida; the Bahamas and south through the Lesser Antilles.

INDO-PACIFIC: The Hawaiian Islands, west to the Philippine Islands, south to New South Wales, Australia and west to East Africa.

*Specimens examined.* WESTERN ATLANTIC. SOUTH CAROLINA: From ocean buoy off Cape Romain (R. Merrill). FLORIDA: off Palm Beach in 30 fathoms (T. McGinty); Lake Worth, Palm Beach County (FSM; J. Schwengel); Boca Raton (T. McGinty); Bear Cut, Key Biscayne (R. Work); Pelican Shoals, Key West (T. McGinty); Tortugas (FSM). BAHAMA ISLANDS: Eight Mile Rock, Grand Bahama Island (MCZ); Drunken

Cays and Cooper Jacks Cays, Great Abaco; 4 miles W of Nassau, New Providence (all R. Robertson); North Cay, New Providence; off Nassau in 4-6 fathoms; North Bimini Island, Bimini Islands; Gun Cay, Bimini Islands; Pigeon Cay, Andros (all T. McGinty). CUBA: Vedado, Habana; Camarioca, Matanzas (both Museo Poey); Carboneras near Río Camarioca, Matanzas (C. J. Finlay); Varadero, Matanzas (C. J. Finlay; Museo Poey); Cayo Santa Maria, off Punta Alegre, Camagüey (R. Humes); Guantánamo Bay (MCZ); near Cienfuegos, Las Villas (Museo Poey). PUERTO RICO: Aguadilla (A. Phares); Rincón Light House, Rincón (G. Warmke). VIRGIN ISLANDS: 1 mile N of Frederiksted, St. Croix (G. Usticke); St. Thomas, Virgin Islands (MCZ). LESSER ANTILLES: Tortola (MCZ); St. Kitts (R. W. Jackson).

INDO-PACIFIC. ELLICE ISLANDS: Funafuti (MCZ). PHILIPPINE ISLANDS: Zamboanga, Mindanao (MCZ). AUSTRALIA: Port Jackson, New South Wales (MCZ). INDONESIA: Manipa Island, Molucca Islands (MCZ).

INDIAN OCEAN ISLANDS: Ceylon (MCZ); Zanzibar Island (MCZ).

### ***Cymatium (Cabestana) felipponei* von Ihering**

Plate 116, fig. 2

*Lotorium felipponei* von Ihering 1907, Anales Museo Nacional de Buenos Aires (3) 7, p. 443, pl. 18, fig. 122a-b (Maldonado, Uruguay).

**Description.** Shell medium in size, reaching 52 mm. (about 2 inches) in length, moderately heavy in structure, imperforate or with a small umbilical chink, and with pronounced sculpture. Color a light reddish brown. Post-embryonic whorls 5, convex and shouldered. Spire moderately extended and produced at an angle of about 45°. Aperture subelliptical, the outer lip margined with rather strong teeth, the inner lip smooth, forming a thickened shield over the parietal area. Columella arched inward; siphonal canal short and curved upward slightly. Axial sculpture consisting of 2 to 4 strong varices; in addition there are numerous and rather fine incised lines which cut across the spiral cords. Spiral sculpture consisting of numerous cords which are somewhat irregular in width, the shoulder cord usually being the largest. Periostracum thin, straw-yellow in color. Operculum and embryonic whorls unknown.

length	width	
52 mm.	31 mm.	Mar del Plata, Argentina (from Carcelles 1944, p. 246)
45	30	Punta del Este, Maldonado, Uruguay
42.5	27	Praia de Guarariba, Vitoria, Estado Espirito Santo, Brasil

**Types.** According to von Ihering 1907, p. 1, the types of this species are in the Museo Nacional de Buenos Aires. The type locality is Maldonado, Uruguay.

**Remarks.** This species appears to be distantly related to *Cymatium cutaceum* Linné of the Mediterranean, from which it differs in being less highly sculptured and having only a slight indication of an umbilicus. See also *Remarks* under *C. labiosum* Wood.

This is a very rare species to judge by the few specimens that are known to exist. We are indebted to Eliseo Duarte of Montevideo, Uruguay for two lots of this species, the one from Vitoria, Brasil extending the known range of this species about 1400 miles to the north.

*Range.* From Vitoria [Victoria], Brasil south to Puerto Quequen, Argentina.

*Specimens examined.* BRASIL: Playa de Guarariba, Vitoria, Est. Espirito Santo (E. Duarte). URUGUAY: Cabo Santa Maria (A. Carcelles); Punta del Este, Maldonado (E. Duarte).

### Subgenus *Ranularia* Schumacher

*Ranularia* Schumacher 1817, Essai d'un Nouveau Système, p. 253.

*Ranula* Schumacher 1817, Essai d'un Nouveau Système, p. 77.

*Tritonocauda* Dall 1904, Smithsonian Miscellaneous Collections 47, p. 133 (type species, *Murex caudatus* Gmelin, original designation). [New name for *Ranularia* 'Schumacher' Fischer, non *Ranularia* Schumacher.]

Type species, *Tritonium clavator* Chemnitz [= *Ranularia longirostra* Schumacher] subsequent designation, Herrmannsen, 1847.

Herrmannsen in his *Indicis Generum Malacozoorum* 2, p. 388, gave the type species as *Tritonium clavator* Chemnitz. However, Schumacher used *longirostra*, with *clavator* Chemnitz given as a synonym.

Schumacher made a curious error when he instituted the name *Ranula* (p. 77) in his generic system, and later (p. 253), he used *Ranularia* referring by number back to *Ranula*. However, his second use carries not only the description but here he cites two species. The brief generic diagnosis under *Ranula* would be unidentifiable standing alone.

The new name *Tritonocauda* introduced by Dall for *Ranularia* Schumacher as used by Fischer (1884, *Manuel de Conchyliologie*, p. 655) was unnecessary and partly in error, for Dall gave as the type, *Murex caudatus* Gmelin, a name not mentioned by Fischer.

Shell medium in size and generally yellowish to brownish in color. Sculpture consisting of a few to several rounded varices, with most species having strongly developed, knobbed, axial costae. Spiral sculpture consisting of fairly strong cords which may be knobbed or beaded. Between these cords there are usually numerous, fine, spiral threads. Whorls convex. Siphonal canal moderately extended. Aperture subcircular with a moderately thickened parietal wall. Periostracum produced in numerous axial blades which are fringed with hair-like processes. Operculum subovate, with a submarginal nucleus located about midway near the parietal border.

### *Cymatium* (*Ranularia*) *caribbaeum*, new name

Plate 111, figs. 3-4; Plate 113, fig. 3; Plate 117, figs. 1-2

*Triton cynocephalum* 'Lamarck' Kiener 1842, *Iconographie des Coquilles Vivantes*, **Triton**, p. 3, pl. 12, fig. 1 (Bahia, Brasil); non *Triton cynocephalum* Lamarck 1816 and 1822.

*Cymatium cynocephalum* 'Lamarck' Johnson 1934, *Proceedings Boston Society Natural History* 40, p. 114 [error for *cynocephalum* Lamarck].

*Description.* Shell medium in size, reaching about 84 mm. (about  $3\frac{1}{4}$  inches) in length, solid, imperforate and strongly sculptured. Color a light tan to a rich cinnamon brown; the varices with alternating bands of tan and white. Occasionally specimens are found in which the white band of the varices extends as a spiral band from varix to varix. Whorls  $5\frac{1}{2}$  to 6, convex and shouldered. Spire short and broad and produced at an angle of about  $65^\circ$ . Aperture subcircular; outer lip thickened and having seven rather coarse denticles. Inner lip consisting of a thickened shield on which there is a series of small

plicae set well within the aperture and not extending to the edge of the shield. The area between the plicae is a dark red-brown. The edge of the lip is usually a light tan or salmon color. Siphonal canal extended and slightly curved upward and to the left. Columella thickened and continued into the inner margin of the siphonal canal. Suture slightly indented. Sculpture consisting of about 7 nodulose, spiral cords, with numerous fine spiral threads between the cords. Axial sculpture consisting of two or three coarsely knobbed varices, the knobs being formed where the spiral cords cross over the varix. Between the varices, the spiral cords support from 8 to 18 small knobs. The knobs on the cords are in axial alignment, but are not noticeably connected. Those on the shoulder cord are usually the largest. Operculum subovate, sculptured with numerous concentric ridges and with the nucleus submarginal, about midway on the parietal side. Periostracum usually deciduous, yellowish to brown in color, thin in texture and consisting of fringed axial blades. Embryonic shell of 3 to 4 whorls which are amber in color, smooth, moderately extended and mainly chitinous. The first post-embryonic whorl is calcareous, spirally ribbed and slightly envelops a part of the embryonic shell.

length	width	
84 mm.	45 mm.	off Key West, Florida
67.5	41	Dry Tortugas, Florida
63	32	Puerto Plata, Santo Domingo
60	33.5	Barbados, Lesser Antilles

*Types.* The holotype of *Triton cynocephalum* Kiener is probably in the Paris Museum. The type locality is Bahia, Brasil.

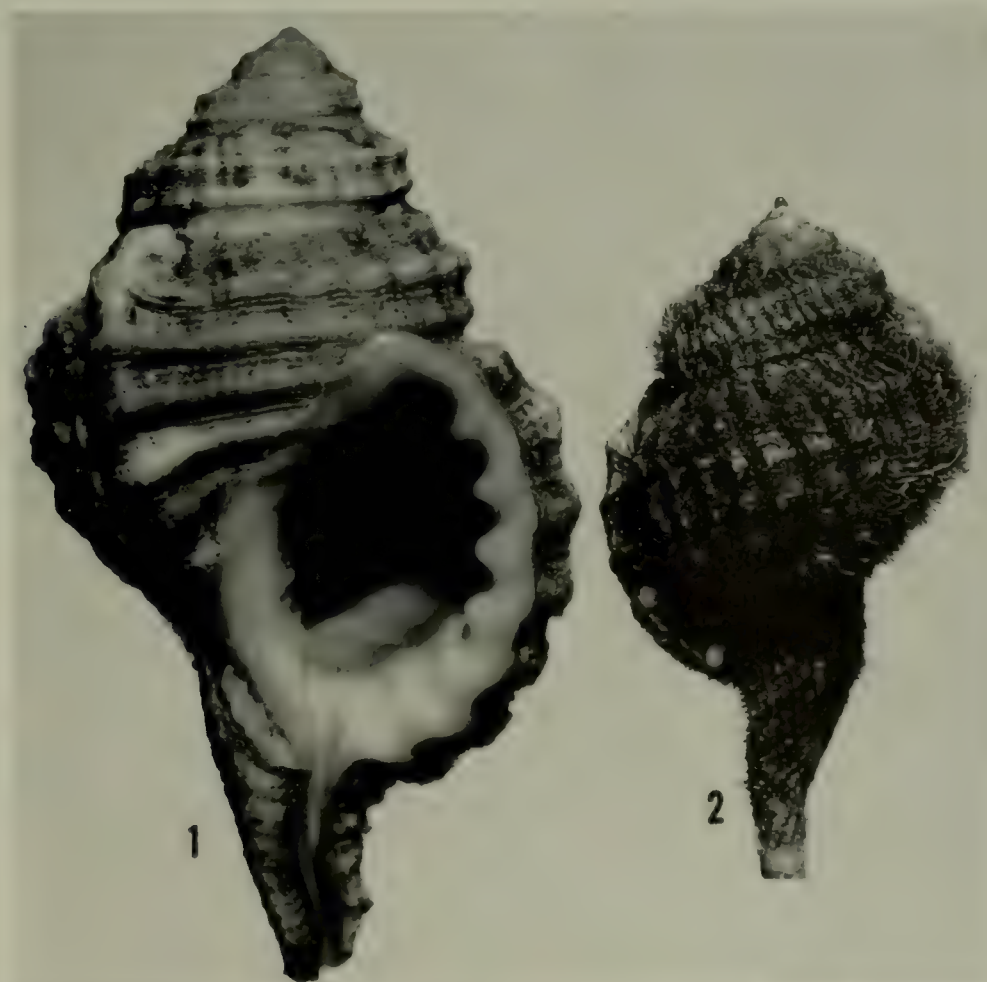


Plate 117. *Cymatium caribbaeum* Clench and Turner. Fig. 1. Cárdenas Keys, Matanzas, Cuba (1.2x). Fig. 2. Bear Cut, Miami, Florida (1.16x).

*Remarks.* It seems incredible that an error should have persisted so long in the naming of this species. So far as we can trace it, this error was initiated by L. C. Kiener in his *Iconographie des Coquilles Vivantes*. He figured under the name of *cynocephalum* Lamarck a shell which is totally different from that originally figured by Lamarck in the *Tableau Encyclopédique et Méthodique*. Lamarck's original figure of *cynocephalum* (1816) is of the species generally known today as *Cymatium cingulatum* of the Panamic Province. Under the section *Notes* at the end of this report we give the synonymy of this Eastern Pacific species and figure a specimen from Bahía Magdalena, Baja California, as well as a copy of Lamarck's original figure for comparison.

*Cymatium caribbaeum* is close in its relationships to *C. sarcostomum* Reeve, from which it differs by having many small uniform knobs on the spiral cords. In *C. sarcostomum* there are only a few large, irregular knobs. From *C. pyrum rehderi* Verrill it differs likewise in the type of knobs; in addition, the plicae on the parietal wall do not extend to the outer margin of the narrow parietal shield of *caribbaeum*, while in *rehderi* they do reach to the outer edge.

*Cymatium caribbaeum* Clench and Turner is confined entirely to the warmer portions of the Western Atlantic.

*Range.* Bermuda, southern Florida, the West Indies and Central Mexico south to Bahia, Brasil.

*Specimens examined.* FLORIDA: Lake Worth (FSM); Bear Cut, Key Biscayne, Miami (R. Work; G. Voss; R. Merrill); West Summerland Key; Missouri Key (both D. and N. Schmidt); Pelican Shoals, off Boca Chica Key (MCZ); Key West (MCZ; H. and K. Johnstone); Tortugas (MCZ; FSM; R. Merrill). BERMUDA: Castle Harbour (dredged dead, H. Moore). BAHAMA ISLANDS: Elbow Cay, Great Abaco (G. and M. Kline; R. Robertson); Alice Town, Bimini Islands (MCZ); Dicks Point, Nassau, New Providence (G. and M. Kline); Simms, Long Island; Matthew Town, Great Inagua (both MCZ). CUBA: Habana, Habana (Museo Poey); Cárdenas, Matanzas (J. Finlay); Cayo Francés, Caibarién, Las Villas (P. J. Bermudez); Cayo Santa Maria, Camagüey (R. Humes); Gibara, Oriente (Museo Poey); Caletón de Don Bruno, Cienfuegos, Las Villas (MCZ); Guantánamo Bay, Oriente (MCZ; Museo Poey). JAMAICA: White House (J. K. Howard). HISPANIOLA: Puerto Plata and Santa Bárbara de Samaná, Santo Domingo (both MCZ). PUERTO RICO: Catano; Rincón; Punta Algarrobo; Punta Guanajibo; Playa de Naguabo (all G. Warmke). VIRGIN ISLANDS: Virgin Gorda (M. W. Dewey); St. John (MCZ); St. Croix (R. Walker; FSM; G. Usticke). LESSER ANTILLES: Barbados (MCZ); Chaguaramas, Trinidad (H. G. Kugler); MEXICO: Tampico, Tamaulipas; Veracruz, Veracruz (both T. Pulley). PANAMA: 2 miles off Colón in 10 fathoms (W. C. Clarke). BRASIL: Itaparica, São Salvador, Bahia (H. S. Lopes).

### ***Cymatium (Ranularia) sarcostomum* Reeve**

Plate 118, figs. 1-5

*Triton sarcostoma* Reeve, April 1844, *Conchologia Iconica* 2, **Triton**, pl. 7, fig. 21a-b (Island of Ticao, Philippines); Reeve, Dec. 1844, *Proceedings Zoological Society London* 12, p. 114.

*Triton moritinctus* Reeve, June 1844, *Conchologia Iconica* 2, **Triton**, pl. 13, fig. 49 (Philippine Islands); Reeve, Dec. 1844, *Proceedings Zoological Society London* 12, p. 115.

*Triton ridleyi* Smith 1890, *Journal Linnean Society London* 20, p. 489, pl. 30, fig. 1 (Fernando Noronha Island, Brasil).

*Description.* Shell medium in size, reaching 60 mm. (about  $2\frac{3}{8}$  inches) in length, solid, imperforate and strongly sculptured. Color light straw-yellow to reddish brown, occasionally banded with white, particularly on the varices. Whorls 5 to 6, convex and shouldered. Spire short and broad and produced at an angle of about  $65^\circ$ . Aperture sub-circular. Outer lip thickened and having 7 rather coarse denticles. Inner lip consisting of a thickened shield on which there is a series of small plicae set well within the aperture and not extending to the edge of the shield. The area between the plicae is usually a dark red-brown, the edge of the lip white to a light tan. Siphonal canal extended and slightly curved upward. Columella thickened and continued into the inner margin of the siphonal canal. Suture slightly indented. Spiral sculpture consisting of 6 to 7 heavy cords with numerous fine spiral threads between the cords. Axial sculpture consisting of 2 or 3 coarsely knobbed varices, the knobs being formed where the spiral cords cross the varices. In addition, there are 4 to 5 axially arranged and somewhat irregular knobbed



Plate 118. *Cymatium sarcostomum* Reeve. Fig. 1. Pelican Shoals, Florida (2x). Fig. 2. Mauritius (2x). Fig. 3. One mile north of Frederiksted, St. Croix, Virgin Islands (1.6x). Fig. 4. Mauritius (1.6x). Fig. 5. St. Croix, Virgin Islands (2.27x).

ridges between the varices. Operculum unknown. Periostracum generally deciduous, light brown in color, thin and consisting of low, axial blades. Embryonic whorls unknown.

length	width	
60 mm.	33.5 mm.	Bermuda
56	37	Calapan, Mindoro, Philippine Islands

*Types.* The type specimens of *C. sarcostomum* Reeve, *C. moritinctus* Reeve, and *C. ridleyi* Smith are probably in the British Museum. The type locality for *sarcostomum* is the Island of Ticao, Philippine Islands.

*Remarks.* This is a rare species in both the Western Atlantic and the Indo-Pacific regions. In the Western Atlantic this species appears to be very closely related to *C. caribbaeum*. The most significant differences separating these species are the fewer and more prominent axial ridges of *sarcostomum*. In this species the axial ridges cross several of the spiral cords while in *C. caribbaeum* the only evidence of the axial ridges is the alignment of the small knobs on the spiral cords.

In the Western Atlantic *C. sarcostomum* appears to occur in deeper water than it does in the Indo-Pacific.

*Range.* WESTERN ATLANTIC: From southern Florida and Bermuda through the West Indies and south to Brasil. This last record is based upon *C. ridleyi* Smith as given in the synonymy above.

INDO-PACIFIC: From the Philippine Islands south through Indonesia and west to Portuguese East Africa. Locard (1897) records this species (as *moritinctum*) from the Cape Verde Islands, West Africa in the Eastern Atlantic.

*Specimens examined.* WESTERN ATLANTIC. FLORIDA: off Palm Beach in 75 fathoms; off Lake Worth in 70 fathoms; S. E. of Government Cut, Miami in 30 fathoms (all T. McGinty); Pelican Shoals, off Key West (MCZ). BERMUDA: (R. Merrill) [dredged dead]. VIRGIN ISLANDS: 1 mile N of Frederiksted, St. Croix (G. Usticke; R. Walker). LESSER ANTILLES: off Sombrero Island in 45 fathoms (Blake, MCZ); Carenage, Trinidad (H. G. Kugler).

INDO-PACIFIC. PHILIPPINE ISLANDS: Subic Bay, Zambales, Luzon; Zamboanga, Mindoro (both MCZ). MOLUCCA ISLANDS: Morotai Island (MCZ). INDIAN OCEAN ISLANDS: Mauritius (MCZ); PORTUGUESE EAST AFRICA: Bazaruto Island, Bazaruto Bay (J. K. Howard).

### **Cymatium (Ranularia) pyrum rehderi** *Verrill*

Plate 119, figs. 2-3

*Cymatium rehderi* Verrill 1950, Nautilus 63, p. 126, pl. 9, fig. 1a-b (25-40 fathoms off Dominica, British West Indies [Lesser Antilles]).

*Description.* Shell medium in size, reaching 92 mm. (about  $3\frac{1}{2}$  inches) in length, solid, rimately umbilicate and strongly sculptured. Color a light reddish brown, the varices having alternating bands of brown and white. Six convex post-embryonic whorls. Spire moderately extended and produced at an angle of  $60^\circ$ . Aperture subovate. Outer lip

thickened and having seven rather coarse denticles. Inner lip consisting of a thickened parietal area on which there are numerous, fine plicae which reach to the outer edge of the thickened area. The spaces between the plicae are reddish brown. Siphonal canal moderately broad and having a narrow aperture which is curved upward and slightly to the left. Columella thickened and continued into the siphonal canal. Suture slightly indented. Sculpture consisting of five or six varices, with five rather large, knobbed, axial ridges between the varices and with numerous, fine axial threads. Spiral sculpture consisting of about seven large cords interspaced with numerous threads. The crossing of the axial and spiral threads creates a beaded appearance. Operculum, periostracum and embryonic shell unknown.

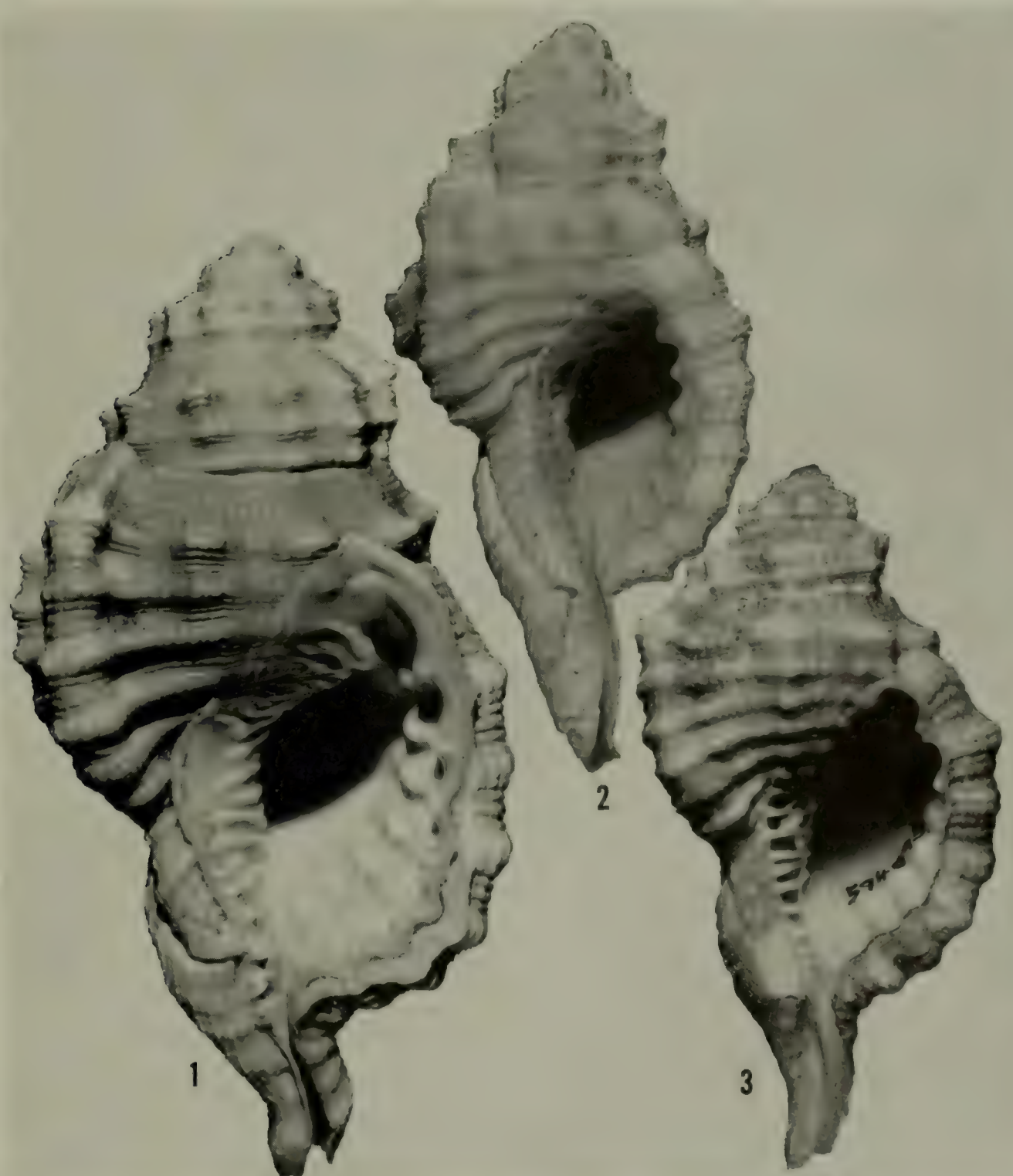


Plate 119. Fig. 1. *Cymatium pyrum* Linné. Okinawa, Ryukyu Islands, Japan (1.18x). Fig. 2. *Cymatium pyrum rehderi* Verrill. Banes, Oriente, Cuba (slightly enlarged). Fig. 3. *Cymatium pyrum rehderi* Verrill. Dominica, Lesser Antilles. Holotype, USNM no. 594095 (1.6x).

length	width	
59 mm.	30 mm.	Holotype of <i>C. p. rehderi</i>
92	46	Banes, Oriente, Cuba
65	33	Matanzas Bay, Cuba

*Types.* The holotype of *Cymatium rehderi* Verrill is in the United States National Museum, no. 594095, from off Dominica, Lesser Antilles in 25–40 fathoms. The measurements of the holotype given by Verrill in the original description were based on the photograph which was enlarged and not the specimen itself. His original measurements gave a length of 75 mm. and a width of 41 mm.

*Remarks.* *Cymatium pyrum rehderi* Verrill is very closely related to *C. pyrum* Linné of the Indo-Pacific region. Actually the only significant differences between this subspecies and the typical form are the smaller size of known specimens of *C. p. rehderi*, the lighter color of its shell and the darker reddish brown of the parietal area. In *C. pyrum* the parietal area is colored the same as the outer surface of the shell. We figure a specimen of *C. pyrum* (Plate 119, fig. 1) for comparison.

In the Western Atlantic *C. p. rehderi* is most easily confused with *C. sarcostomum* Reeve from which it differs by having a more extended spire and having the plicae on the parietal area extend to the outer edge of the thickened parietal lip. In addition, it usually has a longer siphonal canal.

*Range.* This species appears to be restricted to the West Indies, occurring mainly in fairly deep water.

*Specimens examined.* CUBA: Matanzas Bay and Varadero, Matanzas (both C.J. Finlay); Habana, Habana; off Matanzas, Matanzas, Yara, station 3 (N. Lat. 23°8'; W. Long. 81°28') in 200 fathoms (both Museo Poey); Banes, Oriente (C. J. Finlay); Guantánamo, Oriente (USNM). HISPANIOLA: Puerto Plata, Santo Domingo (MCZ). LESSER ANTILLES: Dominica (USNM).

### Subgenus **Cymatriton**, new subgenus

Shells rather small in size and generally uniformly colored a light ashen gray. Axial sculpture consisting of several varices and large, knobbed, axial ridges. Spiral sculpture consisting of large, rounded, cords interspaced with fine thread-like cords. Operculum broadly oval, having a subcentral nucleus and sculptured with concentric growth lines. Embryonic whorls convex, broad and minutely, axially striate.

Type species, *Cymatium nicobaricum* Röding.

### **Cymatium (Cymatriton) nicobaricum** Röding

Plate 111, figs. 5–6; Plate 113, fig. 4; Plate 120, figs. 1–3

*Tritonium nicobaricum* Röding 1798, Museum Boltenianum, p. 126 [refers to Chemnitz 1780, in Martini, Conchylien-Cabinet (1) 4, pl. 130, figs. 1246–1247].

*Triton chlorostomum* Lamarck 1822, Histoire Naturelle des Animaux sans Vertèbres 7, p. 185 (l'Océan des Antilles); Kiener 1842, Iconographie des Coquilles Vivantes 7, Triton, p. 19, pl. 12, fig. 2.

*Triton pulchellus* C. B. Adams 1850, Contributions to Conchology, no. 4, p. 60 (Jamaica).

*Triton chlorostomum pumilio* Mörch 1877, Malakozoologische Blätter 24, p. 29 (no locality given).

*Description.* Shell medium to small in size, reaching 85 mm. (about  $3\frac{3}{8}$  inches) in length, solid, imperforate and strongly sculptured. Color a light ashen gray to rarely a reddish brown. In addition, on most specimens examined, there are flecks of reddish brown, usually appearing on the coarse spiral threads. Interior of aperture a bright orange, the lamellae and palatal denticles white. Occasional specimens have the aperture entirely white. Post-embryonic whorls 7 and strongly convex. Spire extended and produced at an angle of about  $45^\circ$ . Aperture subcircular, with the outer lip greatly thickened when a varix is produced. Parietal lip rather narrow, heavily glazed and with numerous, somewhat irregular, low lamellae. Inner margin of the outer lip with 7 strong denticles which extend well back into the aperture and which may be single or divided. Columella arched inward, with its base continuing into the parietal margin of the siphonal canal. Siphonal canal narrow, moderately long and generally curved upward. Suture slightly indented. Sculpture consisting of 6 strong spiral cords, which are nodulose and are interspaced with fine thread-like cords. Axial sculpture consisting of 5 to 8 rounded varices. There are 3 to 5 larger knobs between each pair of varices. These knobs are variable in size, both as to length and height. Many of them may extend over three of the heavy spiral cords. Periostracum reddish brown, very thin, produced in fringed axial blades and usually deciduous. Operculum broadly oval, with a subcentral nucleus and sculptured with concentric growth lines. Embryonic whorls 6, strongly convex, broad, amber in color and with fine axial striae.

length	width	
85 mm.	49 mm.	Marquesas Islands, Polynesia
78	43	Oshima, Osumi, Ryukyu Islands, Japan
71	43	Bermuda
57.5	29	Punta de los Colorados, Cienfuegos, Cuba
57	34	Long Reef, off Elliott Key, Florida

*Types.* The location of the type specimen of *T. nicobaricum* Röding is unknown. The type figure is in the Conchylien-Cabinet (1) 4, pl. 130, figs. 1246–1247. The holotype of *T. chlorostomum* Lamarck is probably in the Paris Museum. The holotype of *T. pulchellus* C. B. Adams is in the Museum of Comparative Zoology, no. 186135. We here restrict the type locality of *C. nicobaricum* to Jamaica.

*Remarks.* Like others in this family, this is a variable and widely dispersed species, occurring in both the Western Atlantic and the Indo-Pacific regions. We have been unable to separate the Indo-Pacific specimens from those of the Western Atlantic. The greatest variability is expressed in the number and size of the knobs. Some specimens have but a few large and rather irregular knobs while others have numerous, small and quite regular ones.

This species is not closely related to any other in the Western Atlantic. It superficially resembles both *C. pyrum rehderi* and *C. pileare*. However, the extended spire and small and nearly circular aperture of *nicobaricum* readily differentiates it from *rehderi*. From *C. pileare* it differs in having a nearly circular rather than oval aperture, a more twisted siphonal canal and a much coarser, knobbed sculpture.

The embryonic whorls in this species are quite different from those of most other species in the genus *Cymatium* in the Western Atlantic. They are proportionately much wider, stouter and far more conical in shape than other embryonic shells in this genus.

*Range.* WESTERN ATLANTIC: From Palm Beach County, Florida, south to Tortugas; Bermuda and the West Indies, and from Mexico south at least to Honduras. It has been reported from Bahia, Brasil by Lange de Morretes (1949, p. 92).

INDO-PACIFIC: Hawaiian and Marquesas Islands, west to southern Japan, south to New Caledonia and west, through the East Indies and the Indian Ocean Islands to Mauritius. It has been reported from New South Wales, Australia according to D. F. McMichael (in litt.). There are several published records of this species from Madeira and the Canary Islands in the Eastern Atlantic.

*Specimens examined.* WESTERN ATLANTIC. FLORIDA: Jupiter Inlet; Riviera Beach, Palm Beach County (both FSM); Lake Worth, Boynton (FSM; T. McGinty; G. Kline; J. Schwengel); Boca Raton Inlet (J. A. Flowers); Bear Cut, Biscayne Key (H. and K. Johnstone); Long Reef, off Elliott Key (G. Voss); Molasses Reef, off Key Largo (R.

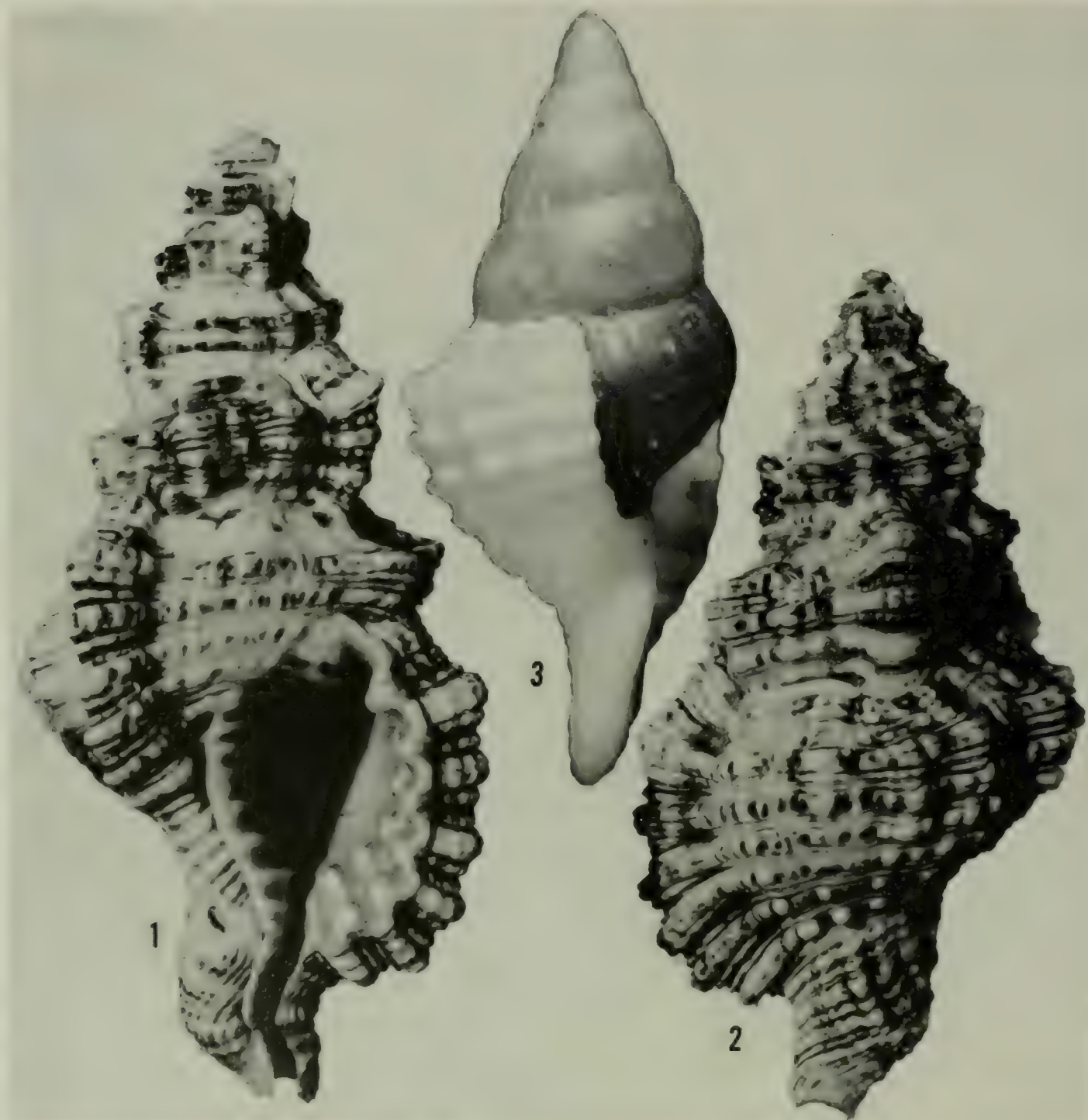


Plate 120. *Cymatium nicobaricum* Röding. Figs. 1-2. Nuevitas, Camagüey, Cuba (2x). Fig. 3. Barbados, Lesser Antilles (embryonic whorls, 13.7x).

Work); Sombrero Key (MCZ); Looe Reef, off Big Pine Key (MCZ); Sand Key, Key West (FSM); Pelican Shoals, Key West (R. Work); Garden Key, Dry Tortugas (FSM). BERMUDA: (ANSP; MCZ). BAHAMA ISLANDS: West End Point, Grand Bahama Island (MCZ); Hope Town, Great Abaco (R. Robertson); Sweetings Village, Great Abaco; Alice Town, North Bimini, Bimini Islands (both MCZ); North Cat Cay and Gun Cay, Bimini Islands; Morgans Bluff, Andros; Clifton Bluff, New Providence (all T. McGinty); Dicks Point, New Providence (MCZ); Harbour Island, Eleuthera (G. Kline); Little San Salvador Island; Northeast Point, 4 miles E of Arthurs Town, Cat Island; Clarence Town, Long Island; Abrahams Bay, Mariguana Island; Matthew Town, Great Inagua (all MCZ). CUBA: Habana, Habana (ANSP); Matanzas Bay, Matanzas (C. J. Finlay); Varadero, Cárdenas (C. G. Aguayo); Playa Comancho, Cárdenas (C. J. Finlay); Cayo Santa María, off Punta Alegre, Camagüey (R. Humes); Nuevitas, Camagüey (C. J. Finlay); Castillo de Jagua, Cienfuegos; Punta de los Colorados, Cienfuegos (both MCZ); Rente, Santiago de Cuba (C. G. Aguayo); Fish Point, Guantánamo Bay (MCZ). HISPANIOLA: Miragoâne, Haiti (W. J. Eyerdam); Montecristi; Puerto Plata; Puerto Sosúa; Santa Bárbara de Samaná, all Santo Domingo (all MCZ). JAMAICA: Port Antonio (MCZ); Whitehouse (J. K. Howard). PUERTO RICO: Mona Island (A. Phares); San Juan; San Geronimo; Camuy; Rincón; Bahía de Añasco; Punta Algarrobo; Mayagüez; Punta Cuchara; near Maunabo (all G. Warmke); Ponce (MCZ). VIRGIN ISLANDS: The Baths, Virgin Gorda; Guana Island, Tortola (both M. W. Dewey); St. John (MCZ); St. Thomas (MCZ; ANSP); 1 mile N of Frederiksted, St. Croix (G. Usticke). LESSER ANTILLES: Barbados; Speyside, Tobago; Carenage, Trinidad (all MCZ). CARIBBEAN ISLANDS: Georgetown, Grand Cayman, Cayman Islands (C. G. Aguayo); Roatan Island, Bay Islands (ANSP). MEXICO: Tuxpan, Veracruz; Veracruz, Veracruz (both T. Pulley); Cabo Catoche, Yucatan (MCZ). HONDURAS: Balfate (FSM).

INDO-PACIFIC. HAWAIIAN ISLANDS: Hilo, Hawaii (MCZ; J. Schwengel); Kihui, Maui (W. Old); Waikiki, Oahu; off Koko Head, Oahu (both MCZ); Fort Kamehameha, Oahu (J. Schwengel); Midway Island (MCZ). LINE ISLANDS: Palmyra Island (MCZ). MARQUESAS ISLANDS: (MCZ). SOCIETY ISLANDS: Punaauia, Tahiti; Vaitape, Bora Bora (both R. Robertson). PHOENIX ISLANDS: Canton Island (MCZ). SAMOAN ISLANDS: Nuuuli, Tutuila (MCZ). ELLICE ISLANDS: Funafuti (MCZ). FIJI ISLANDS: Bega Island (J. Schwengel); Tokoh, 3 miles SW of Levuka, Ovalau (MCZ). GILBERT ISLANDS: Apiang (MCZ). MARSHALL ISLANDS: Ebon Island (MCZ); Rujoru Island and Iqurin Island, Eniwetok Atoll; Bikini Island, Bikini Atoll; Naen Island; Rongelap Atoll (all USNM). MARIANAS ISLANDS: Agaña Bay, Guam; Tinian Island; Tumon Bay, Guam (all MCZ); Saipan (W. Old). CAROLINE ISLANDS: N of Garokottan Island; Garakayo Island; Ngargersiul Island; East Babelthuap Island, all Palau Islands (all ANSP). NEW CALEDONIA: Isle of Pines (MCZ). NEW GUINEA: Gusika, 13 miles N of Finschhafen, Australian New Guinea; Jamna Island, Dutch New Guinea (both MCZ). Abroeki, Aeri Island, Geelvink Bay, Dutch New Guinea (ANSP). AUSTRALIA: Lizard Island, north Queensland (E. Grigg). Gloucester Island, Whitsunday Group, Queensland (W. Old). JAPAN: Tokyo Bay (MCZ). RYUKYU ISLANDS: Oshima, Osumi (MCZ). PHILIPPINE ISLANDS: Guiuan, Samar Island; Lubang Island; Calapan, Mindoro; Siasi Island, Tapul Group, Sulu Islands (all MCZ). MOLUCCA ISLANDS: Bouro Island; Amboyna; Tengah Island, Bouro Island; Dagasoeli Island, North Loloda Island;

Morotai Island (all MCZ). INDIAN OCEAN ISLANDS: Mauritius (MCZ; J. Schwengel).

### Subgenus *Septa* Perry

*Septa* Perry 1810, Arcana, pl. 2, fig. 2; Perry 1811, Conchology, London, pl. 14, fig. 2 (type species, *Septa scarlatina* Perry [= *Murex rubeculus* Linné], monotypic).

*Lampusia* Schumacher 1817, Essai Nouveau Système, p. 350 (type species, *Murex pilearis* Linné, subsequent designation, Herrmannsen 1847).

*Simpulum* Mörch 1852, Catalogus Conchyliorum Comes de Yoldi, p. 108 (type species, *Murex rubeculum* Linné, here selected); non *Simpulum* Fabricius 1823.

*Simplum* Stoliczka 1867, Paleontologia Indica (5) 2, p. 131 (error for *Simpulum* Mörch).

Type species, *Septa scarlatina* Perry [= *Murex rubeculus* Linné], monotypic.

Shells medium to small in size, exceptional shells of *C. pileare* Linné reaching 138 mm. (about  $5\frac{1}{2}$  inches) in length; attenuate, imperforate and generally solid in structure. Color white buff or gray usually with spiral bands of brown or red-brown. Sculpture very variable among the several species, but generally with well-developed varices and strong spiral cords or ribs. Many species have fairly large knobs between the varices and these can be in axial arrangement. Aperture generally with well-developed denticles on the outer lip and many, usually fine plicae on the parietal wall. Siphonal canal short and usually curved upward.

### *Cymatium (Septa) rubeculum occidentale*, new subspecies

Plate 110, fig. 3; Plate 113, fig. 5; Plate 121, figs. 1–3

*Triton rubeculum occidentale* 'Möorch' Tryon 1881, Manual of Conchology (1) 3, p. 12 [nomen nudum].

*Description.* Shell rather small, reaching 32 mm. (about  $1\frac{1}{4}$  inches) in length, rather solid, imperforate and strongly sculptured. Color light brownish yellow with 1 to 2 spiral bands of white. Post-embryonic whorls 5. Spire moderately extended and produced at an angle of about  $55^\circ$ . Aperture subelliptical, the outer lip greatly thickened when a varix is produced. Outer lip with 8 denticles. Inner lip with 14 or 15 rather coarse lamellae. Siphonal canal rather narrow, short and curved upward. Columella nearly straight. Suture slightly indented. Sculpture consisting of 7 or 8 beaded cords of nearly equal strength. Axial sculpture consisting of 3 to 5 ribbed varices. Between the varices there are 3 to 5 weak axial ridges. In addition, there are close-set axial threads which, crossing the spiral cords, produce the beaded effect and give the shell a reticulated appearance. Periostracum light straw-yellow in color and consisting of numerous close-set, low, axial, fringed blades. Operculum unknown. Embryonic shell very small for the size of the adult and consisting of 3 whorls which are light brown in color.

length	width	
32 mm.	17.5 mm.	Holotype, St. Thomas, Virgin Islands
25	16	Paratype, Carboneras, Matanzas, Cuba

*Types.* The holotype is in the Academy of Natural Sciences Philadelphia, no. 36874, from St. Thomas, Virgin Islands, R. Swift, collector. Paratypes from Carboneras,  $1\frac{1}{2}$  miles west of Río Camarioca, Matanzas, Cuba, collected by C. J. Finlay are in the collections of C. J. Finlay, T. McGinty and the Museum of Comparative Zoology, no. 202269.

*Remarks.* We are describing *C. rubeculum occidentale* as a new subspecies though this has long been known under the name *occidentale* Mörch. However, Mörch never described this subspecies. He used the term "occidentale" four times under the genus *Triton* in his paper on the "Synopsis molluscorum marinorum Indiarum occidentalium" (1877, *Malakozoologische Blätter* 24, pp. 14-52). His use of the word "occidentale" was to indicate that he was considering only the specimens from the West Indies and not the Orient. Tryon made the original error in the *Manual of Conchology* (loc. cit.) when he stated that "Möorch made a variety, *occidentale*, but it has no distinctive characters." So far as we can determine no subsequent author referring to this form has ever described or figured it.

The subspecies *occidentale* differs from the typical form by being smaller, having a finer sculpture and being more somberly colored. Typical *rubeculum* of the Indo-Pacific region is usually an intense brick-red or orange-brown, while in *occidentale* the color is usually a dull brownish red to a light brown. In the West Indies this subspecies could be easily confused with small specimens of *C. pileare*, but they may be separated by the obtuse point of the spire and beaded sculpture of *occidentale*.

It would appear that the embryonic shell breaks off very easily in this subspecies. We have seen a few specimens which were collected alive but even these lack the embryonic whorls. Only a single specimen with the embryonic shell still attached has been seen.

*Range.* From southern Florida and probably all of the West Indies west to Central America.

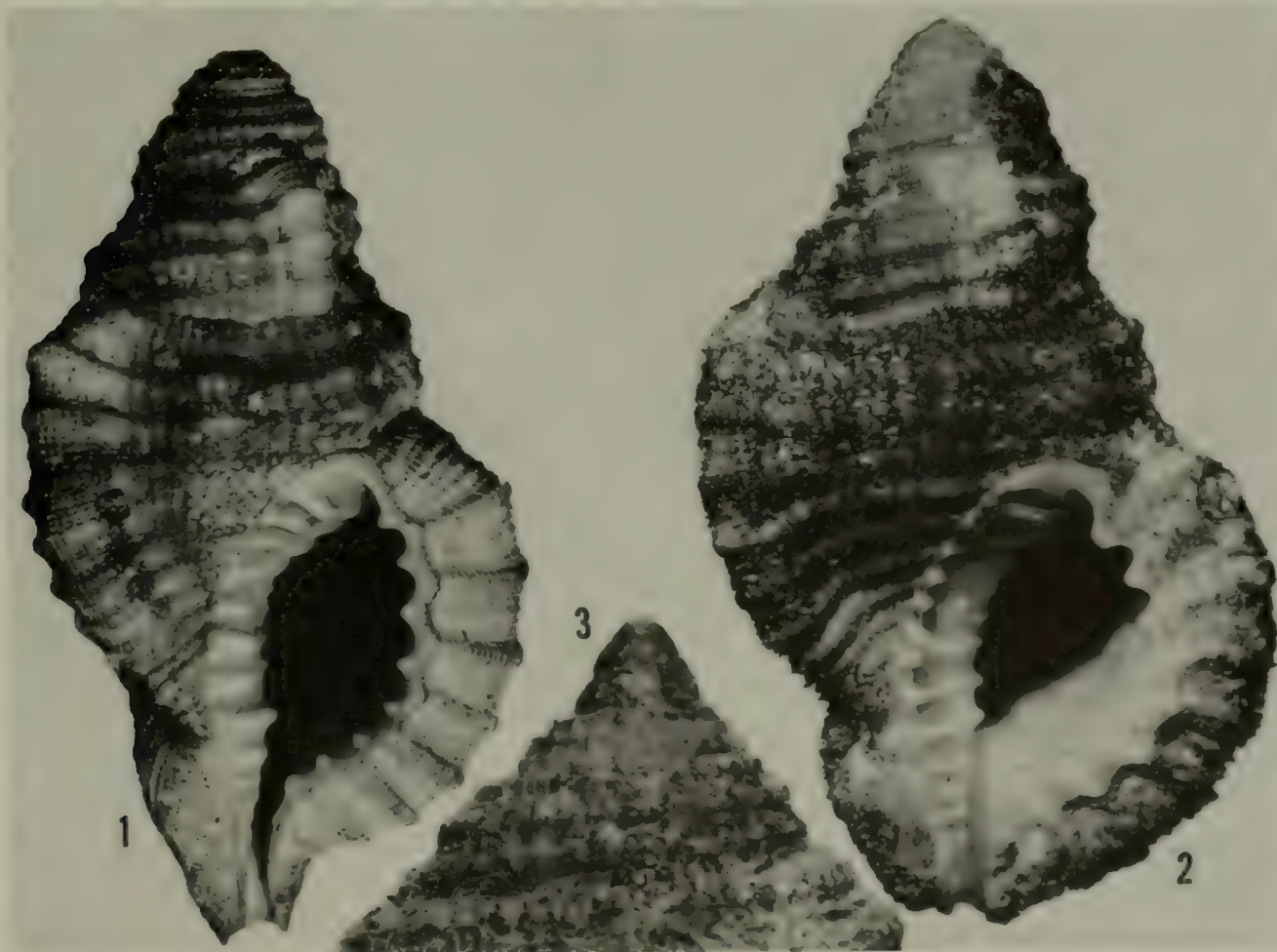


Plate 121. *Cymatium rubeculum occidentale* Clench and Turner. Fig. 1. St. Thomas, Virgin Islands (Holotype, 2.8x). Fig. 2. Pigeon Cays, Andros Island, Bahama Islands (3x). Fig. 3. Off Lantana, Florida in 10 fathoms (embryonic whorls, 10x).

*Specimens examined.* FLORIDA: Palm Beach in 25 and 40 fathoms (both T. McGinty); Ocean Ridge and off Lantana in 10 fathoms, Palm Beach County (both FSM). BAHAMA ISLANDS: Pigeon Cays, Andros (T. McGinty). CUBA: Carboneras,  $1\frac{1}{2}$  miles W of Río Camarioca, Matanzas (C. J. Finlay; T. McGinty; MCZ). VIRGIN ISLANDS: St. Thomas (ANSP). MEXICO: Cabo Catoche, Yucatan (MCZ); Isla Mujeres, Yucatan (Museo Poey).

### Cymatium (Septa) pileare Linné

Plate 112, figs. 1–2; Plate 113, fig. 7; Plate 122, figs. 1–3; Plate 123

*Murex pileare* Linné 1758, Systema Naturae, ed. 10, p. 749 [refers to Gualtierius 1742, pl. 49, fig. G] (M. Mediterraneo).

*Triton pileare* Linné, Lamarek 1816, Tableau Encyclopédique et Méthodique 3, pl. 415, fig. 4a–b; Liste, p. 4; Lamarek 1822, Histoire Naturelle des Animaux sans Vertèbres 7, p. 182 (l'Océan des Antilles).

*Triton aquatilis* Reeve 1844, Conchologia Iconica 2, Triton, pl. 7, fig. 24 (Ticao, Philippine Islands).

*Triton martinianum* d'Orbigny 1847 [in] Sagra, Histoire de l'Île de Cuba, Mollusques 2, p. 162 [new name for *Triton pileare* Lamarek 1822, non *Murex* [*Triton*] *pileare* Linné 1758].

*Litiopa effusa* C. B. Adams 1850, Contributions to Conchology, no. 5, p. 71 (Jamaica); Turner 1956, Occasional Papers On Mollusks 2, p. 136, pl. 21, fig. 3 [is the veliger stage].

*Triton intermedius* Pease 1869, American Journal of Conchology 5, p. 74 (Oahu, Hawaiian Islands).

*Triton martinianum latior* Mörch 1877, Malakozoologische Blätter 24, p. 29 [nomen nudum].

*Triton veliei* Calkins 1878, Records and Proceedings Davenport Academy of Natural Sciences 2, p. 235, pl. 8, figs. 1–2 (southern Florida).

*Dissentoma prima* Pilsbry 1945, Nautilus 59, p. 59, text fig. 1 (off Singers Island near North Inlet, Lake Worth, Palm Beach, Florida); Pilsbry 1949, Nautilus 62, p. 142.

*Description.* Shell moderately large, reaching 138 mm. (about  $5\frac{1}{2}$  inches) in length, solid, imperforate and strongly sculptured. Color, in specimens denuded of their periostracum, a grayish brown to golden brown, generally banded with alternating light and dark bands, particularly on the varices. Within the aperture the color on the outer lip is reddish-brown with 12 to 14 whitish plicae which are often paired. Parietal wall a dark chocolate in color, with numerous fine, irregular, white lamellae. Post-embryonic whorls seven and strongly convex. Spire moderately extended and produced at an angle of  $45^\circ$ . Aperture elliptical with the outer lip greatly thickened when a varix is produced. Parietal lip glazed and with numerous irregular lamellae. Siphonal canal short and generally curved upward. Columella arched inwardly with its base continuing into the parietal margin of the siphonal canal. Suture slightly indented. Sculpture consisting of numerous spiral and generally nodulose cords of unequal strength. Axial sculpture consisting of 3 to 5 strongly knobbed varices. Periostracum generally a light golden brown in color, roughened with numerous periostracal 'hairs' and axial blades. Operculum unguiculate with a marginal nucleus and sculptured with numerous concentric growth ridges. Embryonic whorls four, slightly convex, amber in color and with very fine, axial striae.

length	width	
138 mm.	65 mm.	Philippine Islands
115	56	Rebecca Shoals, 45 miles W of Key West, Florida
111	52.5	Banes, Cuba
100	47	Mauritius
96	47.5	Castle Harbour, Bermuda
94	44	Boca Raton, Florida
84.5	42.5	Biscayne Bay, Florida

*Types.* The only reference given by Linné for *pileare* was to Gualtierius, pl. 49, fig. G and this is the type figure. The locality "M. Mediterraneo" given by Linné is in error. This species does not occur in the Mediterranean. The lectotype of *Litiopa effusa* C.B. Adams is in the Museum of Comparative Zoology, no. 186589 from Jamaica. The lectotype of *T. intermedius* Pease is also in the Museum of Comparative Zoology, no. 191331, from Oahu, Hawaiian Islands. The holotype of *Dissentoma prima* Pilsbry is in the Academy of Natural Sciences Philadelphia, no. 181369. The location of the holotype of *T. veliei* Calkins is unknown to us, but idiotypes from Key West, Florida are in the Museum of Comparative Zoology, no. 150085.



Plate 122. *Cymatium pileare* Linné. Fig. 1. Apiang Island, Gilbert Islands (2x). Fig. 2. Oahu, Hawaiian Islands (lectotype of *Triton intermedius* Pease [= *C. pileare* Linné] MCZ 191331, about 2x). Fig. 3. Venetian Causeway, Biscayne Bay, Florida (1.35x).

As Linné's type locality, as stated above, was in error we take that given by Lamarck as 'l'Océan des Antilles' and restrict it to Jamaica, the locality given by Lister who was Lamarck's first reference.

*Remarks.* This is an exceedingly far-ranging species occurring as it does in the tropical portion of the Western Atlantic and throughout most of the Indo-Pacific. There have been several attempts to separate specimens of the Atlantic from those of the Indo-Pacific, beginning with d'Orbigny who created a new name for Lamarck's use of *pileare* Linné. However, we have been unable to separate specimens from these two very distant areas on any shell characters.

Individual specimens from one locality may show a great deal of variation, but there does not appear to be any geographic significance to these variations.

*Range.* WESTERN ATLANTIC: From Jupiter Inlet, Florida south to Tortugas; off Port Aransas, Texas in deep water (32 fathoms); Bermuda and the West Indies from the Bahamas, and from Veracruz, Mexico south to Bahia, Brasil.

INDO-PACIFIC: The Hawaiian Islands, west to the Ryukyu Islands, Japan and south through the East Indies and the Indian Ocean to East Africa.

*Specimens examined.* WESTERN ATLANTIC. FLORIDA: Jupiter Inlet (FSM); Boynton Inlet, Lake Worth (D. Moore: FSM; T. McGinty); 5 miles S of Delray Beach (FSM); Boca Raton Inlet (E. V. Flowers: FSM; T. McGinty); Pompano (MCZ); Biscayne Bay (R. Humes); off Key Largo (R. Merrill); off Sombrero Light in 35 fathoms (T.



Plate 123. *Cymatium pileare* Linné. Arthurs Town, Cat Island, Bahama Islands (embryonic whorls, 36x).

McGinty); Bahia Honda Key (D. and N. Schmidt); Pelican Shoal, off Boca Chica Key; Key West; Sand Key, off Key West (all MCZ); off Rebecca Shoals, about 45 miles W of Key West in 19 fathoms (H. and K. Johnstone); Dry Tortugas (MCZ). TEXAS: SE of Port Aransas in 32 fathoms (C. L. Branch). BERMUDA: Castle Harbour (dredged fossil, H. B. Moore). BAHAMA ISLANDS: Eight Mile Rock, Grand Bahama (MCZ); Cooper Jacks Cays, Great Abaco (R. Robertson); Alice Town, North Bimini (MCZ); Gun Cay, Bimini (T. McGinty); Middle Bight, Andros; Dicks Point, Nassau, New Providence (both G. Kline); Savannah Sound, Eleuthera; Orange Creek, near Arthurs Town, Cat Island; Clarence Town, Long Island; Watling Island; Fortune Island; Cay Sal, Cay Sal Bank (all MCZ). CUBA: Puerto Esperanza, Pinar del Río; Habana, Habana; Camarioca, Matanzas; Matanzas, Matanzas (all Museo Poey); Varadero, Matanzas (J. Finlay); Caibarién, Las Villas (MCZ); Cayo Maja Figuro, Punta Alegre, Camagüey (R. Humes); Banes, Oriente (J. Finlay); Levisa Bay, Mayari, Oriente (A. Quiñones); Maisí, Oriente (Museo Poey); Cuesco Beach, Guantánamo Naval Base (MCZ); Nispero, Santiago, Oriente (Museo Poey); Caletón de Don Bruno, Cienfuegos (MCZ). JAMAICA: Port Antonio (MCZ; ANSP); Whitehouse (J. K. Howard). HISPANIOLA: Jérémie and Miragoâne, Haiti; Montecristi, Puerto Plata, and Puerto Sosúa, Santo Domingo (all MCZ). PUERTO RICO: Mona Island (MCZ); San Juan (D. Thomas; R. Work); Arecibo (G. Warmke); Bahía de Aguadilla (A. Phares); Rincón; Bahía de Añasco; Mayagüez; Punta Guanajibo; Guanica (all G. Warmke; MCZ); Ponce (MCZ); near Maunabo (G. Warmke). VIRGIN ISLANDS: Frederiksted, St. Croix (G. Usticke; MCZ); St. John; St. Thomas (both MCZ); Guana Island, Tortola; The Baths, Virgin Gorda (both M. W. Dewey). LESSER ANTILLES: St. Kitts; Guadeloupe (both ANSP); St. Lucia; Barbados (both MCZ); Buccoo Reef, Tobago (MCZ; K. Anderson); Chaguaramas, Trinidad (H. G. Kugler); Grenada (K. Anderson). CARIBBEAN ISLANDS: Southwest Point, Grand Cayman, Cayman Islands (ANSP). MEXICO: Tuxpan, Veracruz; Cabo Catoche, Yucatan; Isla Mujeres, Yucatan (all MCZ). HONDURAS: Puerto Cortez (MCZ); Belfate (FSM). PANAMA: 2 miles off Colón; Brujas Point, Canal Zone (both W. G. Clark). DUTCH GUIANA: Corentyne River (dead, H. G. Kugler); BRASIL: Itaparica, Ilha de Itaparica, Bahia (H. S. Lopes).

INDO-PACIFIC. HAWAIIAN ISLANDS: Fort Kamehameha, Oahu (J. Schwengel); Pearl Harbor, Oahu (V. D. Spicer). LINE ISLANDS: Kingman Reef, 33 miles NW of Palmyra Island (J. Schwengel). SOCIETY ISLANDS: Arue, Tahiti; Vaitape, Bora Bora (both R. Robertson). GILBERT ISLANDS: Apiang (MCZ). CAROLINE ISLANDS: Garakayo Island, Palau Islands; Babelthuap, Palau Islands (both ANSP). MARIANAS ISLANDS: Saipan (W. Old). FIJI ISLANDS: Bega Island (J. Schwengel). JAPAN: Ryukyu Islands (MCZ). PHILIPPINE ISLANDS: Subic Bay, Zambales, Luzon; Calapan, Mindoro; Tagbac, Lubang; Araceli, Dumarán Island, Palawan; Davao, Mindanao; Zamboanga, Mindanao (all MCZ). NEW GUINEA: Island 5 miles NW of Rani Island, Schouten Islands; Abroeki, Aori Island, Geelvink Bay; Samberbaba, Japen Island, all Dutch New Guinea (all ANSP); Jamna Island, Dutch New Guinea (MCZ); Madang Island, Finschafen, Australian New Guinea (E. Grigg). AUSTRALIA: Augustus Island, northern Western Australia (MCZ); Low Wooded Isle and Portland Roads, both northern Queensland (both E. Grigg). INDONESIA: Toelehoe, Amboina (MCZ); Woda Island, Halmahera, Molucca Islands; Morotai Islands; St. Nicholas Bay, Bali Island, Greater Sunda Islands (all MCZ). INDIAN OCEAN ISLANDS: 12 miles N of Trincomalee, Ceylon (W. Old);

Mauritius: Zanzibar (both MCZ): Nosy Bé, Madagascar (A. Humes). PAKISTAN: Makran Coast (MCZ). ADEN: (MCZ). KENYA: Mombassa (MCZ); Kilifi (E. Grigg). PORTUGUESE EAST AFRICA: Bazaruto Island, Bazaruto Bay (J. K. Howard).

### *Cymatium (Septa) krebsii* Mörch

Plate 112, figs. 3-4; Plate 124, figs. 1-4

*Triton krebsii* Mörch 1877, Malakozoologische Blätter 24, p. 30 (St. Thomas and St. Croix [Virgin Islands]); Kobelt 1878, Conchylien Cabinet (2) 3, pt. 2, p. 265, pl. 70, figs. 3-4.

*Cymatium (Lampusia) krebsii* Mörch. Rehder and Abbott 1951, Revista de la Sociedad Malacológica 8, pl. 8, fig. 6.

*Lampusia? pharcida* Dall 1889, Bulletin Museum Comparative Zoology 18, p. 227, pl. 36, fig. 2 (Blake, station 293, N. Lat.  $13^{\circ}14'23''$ ; W. Long.  $59^{\circ}39'10''$ , off Barbados in 81 fathoms).

**Description.** Shell medium in size, reaching 73 mm. (about 3 inches) in length, solid, imperforate and strongly sculptured. Color entirely white or white with spiral bands of yellowish brown in the grooves between the cords. Interior of the aperture white. Post-embryonic whorls 7 and strongly convex. Spire extended and produced at an angle of about  $37^{\circ}$ . Aperture nearly vertical and narrowly elliptical. Outer lip greatly thickened when a varix is produced. Parietal lip rather narrow and heavily glazed. On the outer lip there are 6 or 7 strong denticles which extend well into the aperture. On the inner lip, at the upper end there is a strong lamella which forms the margin of the anal canal. On the columella and well within the aperture there are two large and somewhat irregular lamellae. In addition, between the anal lamella and the base of the siphonal canal there are numerous and very fine thread-like lamellae. Columella slightly arched inwardly, with its base continuing into the parietal margin of the siphonal canal. Siphonal canal narrow, rather short and curved upward. Suture slightly indented. Sculpture consisting of from 5 to 7 strong, nodulose varices. Between the varices there are 5 or 6 somewhat irregular and strongly nodulose, axial ridges. These are crossed by 6 or 7 heavy spiral cords. Between these cords there are three subequal but rather fine thread-like cords. Periostracum thin, deciduous, roughened and golden-brown in color. Operculum unguiculate with a marginal nucleus and numerous concentric growth lines. Embryonic whorls  $3\frac{1}{2}$  to 4, smooth, straw-yellow in color, narrow, extended and with microscopic axial striae.

length	width	
73 mm.	37 mm.	off New Ground Shoals, Dry Tortugas, Florida
58.5	29	Punta Guanajibo, Puerto Rico

**Types.** The holotype of *C. krebsii* Mörch is probably in the Universitetets Zoologiske Museum, København, Denmark. There are two paratypes from the Swift Collection in the Academy of Natural Sciences Philadelphia, no. 42605. The holotype of *C. pharcidum* Dall is in the United States National Museum, no. 94887. The type locality is here restricted to St. Thomas, Virgin Islands, the locality from which Swift's material came.

**Remarks.** *Cymatium krebsii* Mörch is a very rare species to judge by the few specimens in museum collections. It differs from *C. nicobaricum* in the shape of the aperture and the lack of color in the aperture, though in general sculptural characters it appears to be quite close to that species. From *C. pileare* Linné it differs in general shape and in the

lack of color in the aperture. In addition, it is far more nodulose. From both *C. nicobaricum* and *C. pileare* it differs by having two rather large columellar lamellae. See also *Remarks* under *C. gemmatum* Reeve.

*Cymatium krebsii* is apparently related to *C. corrugatum* Lamarck of the Eastern Atlantic, both species agreeing in the approximate shape of the more or less vertical and narrow, elliptical aperture. In both species the aperture is white and both have the large columellar lamellae. *C. krebsii* differs from *corrugatum* in being somewhat smaller and in being far more nodulose.

*Range.* From Palm Beach County, Florida to Dry Tortugas and south through the West Indies.

*Records.* FLORIDA: off Delray Beach in 65 and 80 fathoms (FSM; T. McGinty); off Palm Beach in 25 to 75 fathoms (T. McGinty; J. Schwengel; ANSP); Nellies Point, Fish Haven, Palm Beach County (ANSP); North Inlet, Lake Worth (T. McGinty); SE of Miami in 30 fathoms (T. McGinty); Little Duck Key (J. Schwengel); off Sombrero Light, E of Marathon in 37 fathoms (T. McGinty); Bahia Honda Key; off Key



Plate 124. *Cymatium krebsii* Mörch. Fig. 1. Off Sombrero Key, Florida (about 1.4x). Fig. 2. St. Thomas, Virgin Islands (paratype, 1.32x). Fig. 3. Off Barbados, Lesser Antilles (Holotype of *C. pharcidum* Dall [= *C. krebsii* Mörch], 5x). Fig. 4. Lake Worth, Palm Beach Co., Florida (showing embryonic whorls, 8x).

West in 18 fathoms (both H. and K. Johnstone); off Sand Key Light, Key West in 70 fathoms (T. McGinty); off New Ground Shoals, Dry Tortugas (USNM); off Tortugas in 18-20 fathoms (T. McGinty); off Destin in 14 fathoms (ANSP; T. McGinty); off Panama City in 21 fathoms (T. McGinty). PUERTO RICO: Punta Guanajibo (A. Phares). VIRGIN ISLANDS: St. Thomas (ANSP). LESSER ANTILLES: off Scarborough, Tobago in 36 fathoms (MCZ). VENEZUELA: Cubagua Island (MCZ).

**Cymatium (Septa) gemmatum** Reeve

Plate 110, fig. 2; Plate 113, fig. 6; Plate 125, figs. 1-2

*Triton gracilis* of authors, not of Reeve 1844.

*Triton gemmatum* Reeve 1844, Conchologia Iconica 2, Triton, pl. 15, fig. 60 a-b (Island of Ticao, Philippine Islands).

*Triton mundum* Gould 1849, Proceedings Boston Society Natural History 3, p. 143 (Tutuila, Samoan Islands).

**Description.** Shell small, reaching 43 mm. (about  $1\frac{3}{4}$  inches) in length, rather solid, imperforate and strongly sculptured. Color yellowish brown, with patches of reddish brown on the varices. Interior of the aperture white. Post-embryonic whorls six and convex. Spire extended and produced at an angle of about  $50^\circ$ . Aperture elliptical. Outer lip thickened, the inner edge with 12 denticles which are grouped in pairs. Upper portion of the parietal wall with a large tooth formed to create the anal canal. Central portion of the parietal wall with very weak lamellae. At the base of the aperture the parietal lamellae increase in size and then diminish along the siphonal canal. Siphonal canal long, narrow, almost closed and curved slightly upward. Suture slightly indented. Axial sculpture consisting of 2 or 3 varices. Between the varices there are 3 or 4 rather weak axial ridges; in addition, there are numerous very fine, axial threads. Spiral sculpture consisting of numerous moderately heavy cords which are interspaced with finer cords. Embryonic whorls 5, yellowish amber in color, rather narrow and glass-like. Operculum unguiculate with a marginal nucleus at the base and with concentric growth lines. Periostracum thin, straw-yellow in color, smooth over most of the shell but producing fringed blades on the varices and axial ribs.

length	width	
43.5 mm.	21 mm.	Oshima, Osumi, Japan
36	18	Bazaruto Bay, Portuguese East Africa
34	14	Cays off Cárdenas, Matanzas, Cuba
28.5	13.5	Puerto Plata, Santo Domingo

**Types.** The types of *C. gemmatum* Reeve are probably in the British Museum; the type locality is the Island of Ticao [off Masbate], Philippine Islands. The location of the holotype of *C. mundum* Gould is unknown. An idio type is in the Museum of Comparative Zoology.

**Remarks.** This species has long been known under the name of *gracilis* Reeve, but it certainly does not fit the description and figure of that species. Reeve's figure gives no indication of the enlarged columellar plicae and the large parietal lamella which aids in forming the clearly defined anal canal. Both of these characters are exhibited in the figure of *gemmatum*.

This is a rare species; it has been taken from low water to depths of 117 fathoms.

In relationship it appears to be nearest to *C. krebsii* Mörch. It differs from that species by having a smaller aperture and by having the columellar plicae proportionately smaller. Adult specimens of *C. gemmatum* are very much smaller, being only about half the size of an adult *C. krebsii*. However, it is often difficult to differentiate the young of *krebsii* from adult *gemmatum*.

The range given below is only an indication of the range of this species. It probably occurs throughout all of the tropical portions of both the Indo-Pacific and the Western Atlantic.

**Range.** WESTERN ATLANTIC: Southern Florida from Palm Beach County to the lower Florida Keys and the West Indies, south to Trinidad.

INDO-PACIFIC: The Hawaiian Islands, west to southern Japan, south to northern Australia and west to Portuguese East Africa.

**Specimens examined.** WESTERN ATLANTIC. FLORIDA: Boynton Beach (T. McGinty); off Boynton, Palm Beach County (from stomach of a moray in 10 fathoms); 2 miles S of Boynton in 10 fathoms (both FSM); off Lantana in 25 fathoms; off Palm Beach Inlet in 25 and 40 fathoms; Boca Raton (all T. McGinty); off Hillsborough Light, Brevard County in 20 fathoms (FSM); off Miami in 27 fathoms (T. McGinty); off The Elbow, Key Largo in 66 fathoms; 5 miles off Carysfort Light, Key Largo in 96 and 117 fathoms (all MCZ). BERMUDA: St. George (T. McGinty). BAHAMA ISLANDS: Channel Cay, Great Abaco (R. Robertson); Nassau and Clifton Bluff, New Providence; North Bimini and Gun Cay, Bimini Islands (all T. McGinty). CUBA: Arenas de la Chorrera, Habana



Plate 125. *Cymatium gemmatum* Reeve. Fig. 1. Cárdenas Keys, Matanzas, Cuba (2.9x). Fig. 2. North Bimini Island, Bimini Islands, Bahamas (8x).

(MCZ): Cays off Cárdenas, Matanzas; Varadero Beach, Matanzas (both C. J. Finlay). HISPANIOLA: Cap Haitien, Haiti (T. McGinty); Caye Carenge, Boucassin, Haiti (R. Work); Puerto Plata, Santo Domingo (MCZ). PUERTO RICO: Arecibo; Punta Algarrobo (both U.P.); Rincón (G. Warmke). VIRGIN ISLANDS: St. Croix (FSM). LESSER ANTILLES: off Barbados, *Blake*, in 50 and 100 fathoms; 2 miles S of Fort George, Scarborough, Tobago in 36 fathoms (both MCZ).

INDO-PACIFIC. HAWAIIAN ISLANDS: off Koko Head, Oahu (MCZ). SAMOAN ISLANDS: Vaoto, Vaialele Bay, Upolu Island (ANSP). HOWLAND ISLAND (MCZ). GILBERT ISLANDS: Apiang (MCZ). CAROLINE ISLANDS: Ponape (MCZ); Koror, Palau Islands (ANSP). JAPAN: Oshima Osumi (MCZ); Chishima, Okinawa, Ryukyu Islands (J. Schwengel). PHILIPPINE ISLANDS: Lubang (MCZ). AUSTRALIA: Debris Bay, Cape Grafton, near Cairns, Queensland (J. K. Howard); Murray Island, Great Barrier Reef, Queensland (MCZ). INDIAN OCEAN ISLANDS: Ceylon; Zanzibar (both MCZ). PORTUGUESE EAST AFRICA: Bazaruto Island, Bazaruto Bay (J. K. Howard).

### Subgenus *Gutturnium* Mörch

*Gutturnium* Mörch 1852, Catalogus Conchyliorum Comes de Yoldi, p. 109.

Type species, *Triton tuberosum* Lamarck [= *Distorsio muricina* Röding], subsequent designation, Dall 1904.

Shell medium in size and gray to brown in color. Sculpture consisting of a few varices, with one to four knobbed axial ridges. Spiral sculpture of numerous beaded cords, with finer cords between them. Whorls convex. Siphonal canal narrow, moderately extended

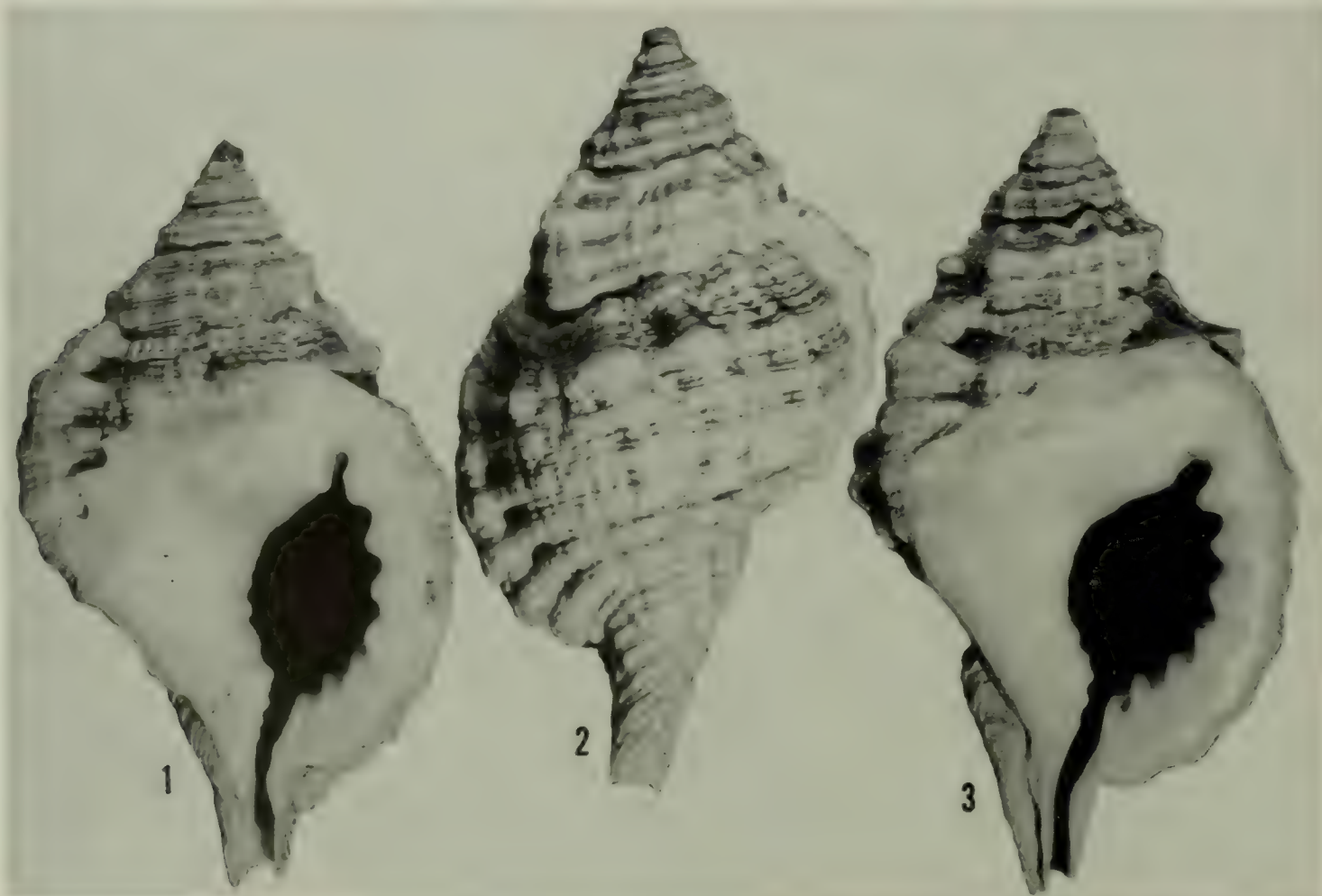


Plate 126. *Cymatium muricinum* Röding. Figs. 1-2. Caletón de Don Bruno, Cienfuegos, Cuba (2.16x). Fig. 3. Savu Savu Bay, Vanua Levu Island, Fiji Islands (2.16x).

and directed upward. Aperture subcircular and having a broad parietal shield. Periostracum thin and deciduous. Operculum unguiculate with an apical nucleus and sculptured with concentric growth lines.

There is only one species in this subgenus in the Western Atlantic.

### **Cymatium (Guttarium) muricinum Röding**

Plate 112, figs. 5–6; Plate 113, fig. 8; Plate 126, figs. 1–3; Plate 127

*Distorsio muricina* Röding 1798, Museum Boltenianum, p. 133 [refers to Martini (1) 3, pl. 112, figs. 1050–1051].

*Murex pyrum* Gmelin 1791, Systema Naturae, ed. 13, p. 3535 [in part, reference to Martini (1) 3, pl. 112, figs. 1050–1051, only].

*Triton tuberosum* Lamarek 1822, Histoire Naturelle des Animaux sans Vertèbres 7, p. 185 (l'Océan des Grandes Indes). [Refers to Martini (1) 3, pl. 112, figs. 1050–1051.]

*Triton pyriformis* Conrad 1849, Journal Academy Natural Sciences Philadelphia (n.s.) 1, p. 211 [refers to Martini (1) 3, pl. 112, figs. 1050–1051].

*Triton productum* Gould 1852, United States Exploring Expedition 12, Mollusca, p. 240 (Fiji Islands).

*Triton antillarum* d'Orbigny 1842 [in] Sagra, Histoire de l'Ile de Cuba, Mollusques 2, p. 161, pl. 23, fig. 20 (Cuba).

*Litiopa obesa* C. B. Adams 1850, Contributions to Conchology, no. 5, p. 71 (Jamaica) [embryonic shell].

**Description.** Shell medium in size, reaching about 75 mm. (about 3 inches) in length, solid, imperforate and strongly sculptured. Color dull grayish brown, with occasional banded specimens having broad bands of dark reddish brown; often these bands are visible only in transmitted light. Lip and parietal shield white to light ivory and highly glazed. Interior of aperture a dark reddish brown. Post-embryonic whorls 5 to 7, and strongly convex. Spire elevated and produced at an angle of about 60°. Aperture subcircular with the outer lip greatly thickened when a varix is produced. Parietal lip glazed to form a rather broad shield. There are 4 or 5 inconspicuous plicae at the base of the columella. The outer lip has 7 strongly developed crenulations. Siphonal canal extended, though variable in length, and directed upward at an angle of about 55°. Columella slightly arched inwardly, its base continuing into the parietal margin of the siphonal canal. Suture irregular and somewhat indented. Sculpture consisting of numerous spiral and nodulose cords of unequal strength, and numerous fine, thread-like ridges. Axial sculpture consisting of 7 or 8 nodulose varices. In addition there are 2 to 3 knobbed ridges between the varices which give the shell a very rugose appearance. Periostracum produced in numerous rows of thin low blades, light brown in color and deciduous. Operculum unguiculate, its nucleus apical and the surface roughened by numerous fine concentric ridges.

length	width	
75 mm.	37.5 mm.	Mokuole Island, Kaneohe Bay, Oahu, Hawaiian Islands
71	33	Port Antonio, Jamaica
58	28	Mauritius
49	31	Caleton de Don Bruno, 4 mi. SW of Cienfuegos, Cuba
46	25.5	Savusavu, Vanua Levu, Fiji Islands

**Types.** The type figures are here selected to be Martini, Conchylien-Cabinet (1) 3, pl. 112, figs. 1050–1051, for *muricinum* Röding, *tuberosum* Lamarek and *pyriformis* Conrad, as indicated in the synonymy, were all based on these figures. The type of *antillarum* d'Orbigny is in the British Museum (Natural History). The holotype of *productum*

Gould is probably in the United States National Museum. The type locality as given by Martini is the Coromandel Coast, India. The holotype of *L. obesa* C. B. Adams is in the Museum of Comparative Zoology, no. 186594.

*Remarks.* So far as we can detect there is no appreciable difference between the Western Atlantic and the Indo-Pacific specimens of the species. It is quite variable in size at maturity and specimens also vary as to the number and development of the nodulose varices and ridges.

*Range.* WESTERN ATLANTIC: Bermuda and from Jupiter Inlet, Florida and Veracruz, Mexico throughout the West Indies and south to Estado do Paraná, Brasil (Morretes, 1949).

INDO-PACIFIC: From the Hawaiian Islands south to the Marquesas, west to the Ryukyu Islands, the Philippines south to Australia and the East Indies and west in the Indian Ocean to Zanzibar.

*Specimens examined.* WESTERN ATLANTIC. FLORIDA: Jupiter Inlet (FSM); Lake Worth, Boynton (MCZ; FSM; ANSP; T. McGinty); Boca Raton (J. N. Flowers); off Fort Lauderdale (MCZ); Key Biscayne (J. K. Howard; R. Work); Grassy Key (ANSP); Boca Chica Key (D. and N. Schmidt); Pelican Shoals, Key West; Dry Tortugas (both FSM). BERMUDA: Castle Harbour (MCZ). BAHAMA ISLANDS: North Point,



Plate 127. *Cymatium muricinum* Röding. Miragoâne, Haiti (to show embryonic whorls, 30x).

Elbow Cay, Great Abaco (R. Robertson); Settlement Point, Grand Bahama; Adelaide, New Providence (both MCZ); Lyford Cay, New Providence (G. & M. Kline); South Bimini; Little San Salvador; Arthurs Town, Cat Island; Clarence Town, Long Island (all MCZ); Man Island, Eleuthera (G. and M. Kline). CUBA: Varadero, Matanzas (ANSP; J. Schwengel); Cárdenas, Matanzas (MCZ; J. Finlay); Cayo Francés, Caibarién, Las Villas (P. J. Bermúdez); Cayo Santa María, Camagüey (R. Humes); Banes, Oriente; Santiago, Oriente (both C. G. Aguayo); Blue Beach, Guantánamo Naval Base, Oriente; Caletón de Don Bruno, Cienfuegos (both MCZ). HISPANIOLA: Miragoâne, Haiti; Montecristi; Puerto Plata and Santa Bárbara de Samaná, all Santo Domingo (all MCZ). JAMAICA: Port Antonio (MCZ). PUERTO RICO: San Juan (D. Thomas); north of Veja Baja (MCZ); Arecibo; Aguada (both G. Warmke); Bahía de Añasco; Punta Guanajibo; Mayagüez; Ponce (all MCZ; UP; ANSP); Puerto Patillas (G. Warmke). VIRGIN ISLANDS: St. Thomas; St. John (both MCZ); Guana Island, Tortola (M. W. Dewey); St. Croix (FSM; ANSP). LESSER ANTILLES: Guadeloupe (ANSP); Barbados (MCZ). CARIBBEAN ISLANDS: Curaçao, Dutch West Indies. MEXICO: Veracruz, Veracruz (T. Pulley; MCZ). PANAMA: Colón (ANSP).

INDO-PACIFIC. HAWAIIAN ISLANDS: Mokuole Island, Kaneohe Bay, Oahu; Kawaihae, Hawaii; Hilo Bay, Hawaii (all MCZ). LINE ISLANDS: Palmyra Island (MCZ). BAKER ISLAND (MCZ). SOCIETY ISLANDS: Punaauia and Arue, Tahiti; Teavaro-Teaharoa, Moorea (all R. Robertson). MARSHALL ISLANDS: Ebon Island (MCZ). GILBERT ISLANDS: Apiang (MCZ). MARIANAS ISLANDS: Tumon Bay, Guam (MCZ); Apra Harbor, Guam (W. Old). CAROLINE ISLANDS: Ponape (MCZ); Peleliu Island and Koror Island, Palau Islands (both ANSP). FIJI ISLANDS: Valanga Bay, Vanua Levu; Suva, Viti Levu (both MCZ); Bega Island (J. Schwengel). NEW CALEDONIA (MCZ). NEW GUINEA: Sowek, Soepiori Island, Schouten Islands, Dutch New Guinea (ANSP). AUSTRALIA: Two Isles, Queensland (E. Grigg). JAPAN: Ookamijima, Taira, Miyako, Ryukyu Islands; Machinato, Okinawa, Ryukyu Islands (both MCZ). PHILIPPINE ISLANDS: Guiuan, Sámar; Calapan, Mindoro; Lubang; off Aborlan, Palawan (all MCZ). MOLUCCA ISLANDS: Tengah Island, off Bouro Island; Bouro Island; Amboina Island (all MCZ). INDIAN OCEAN ISLANDS: Hikkadua, Ceylon (ANSP); Mauritius; Zanzibar (both MCZ). KENYA: Kilifi (E. Grigg). PORTUGUESE EAST AFRICA: Bazaruto Island, Bazaruto Bay (J. K. Howard); Mozambique (J. Schwengel).

### Subgenus *Monoplex* Perry

*Monoplex* Perry 1811, Conchology, pl. 3, fig. 3.

Type species, *Monoplex australasiae* Perry [= *Cymatium parthenopeum* von Salis], here selected.

Both Herrmannsen 1846 and Gray 1847 gave *M. olearium* as the type species of *Monoplex*, but this name was not included among the species described by Perry for this subgenus.

Shell medium to moderately large in size and generally yellowish to brownish in color. Sculpture consisting of large spiral cords and occasionally of varices. The shell is usually rimately umbilicate. Periostracum heavy, produced in fringed axial blades and usually deciduous. Operculum unguiculate, with an apical nucleus.

## Cymatium (Monoplex) parthenopeum<sup>1</sup> von Salis

Plate 110, fig. 4; Plate 112, figs. 7-8; Plate 113, figs. 9-10; Plate 128, figs. 1-3

*Triton olearius* of authors not the *Murex olearium* Linné 1758 and 1767. We here select Linné's reference to Gualtieri 1742, pl. 50, fig. A to be the type figure of *M. olearium* Linné which is an earlier name for *Ranella gigantea* Lamarck.

*Murex costatus* Born 1778, Index Rerum Naturalium Musei Caesarei Vindobonensis **1**, p. 295 (locality unknown); Born 1780, Testacea Musei Caesarei Vindobonensis, p. 297 [refers to Seba 1758, Thesauri **3**, pl. 57, fig. 31], non *Murex costatus* Pennant 1777.

*Murex parthenopeus* von Salis 1793<sup>2</sup> Reisen in versch. Prov. Königreich Neapel **1**, p. 370, pl. 7, fig. 4; 1795, English translation by Aufrere, p. 462, pl. 7, fig. 4 (Bay of Naples).

*Triton succinctum* Lamarck 1816, Tableau Encyclopédique et Méthodique **3**, pl. 416, fig. 2; Liste, p. 5; Lamarck 1822, Histoire Naturelle des Animaux sans Vertèbres **7**, p. 181 (mers de la Nouvelle-Hollande).

*Triton americanum* d'Orbigny 1842 [in] Sagra, Histoire de l'Île de Cuba, Mollusques **2**, p. 163, pl. 23, fig. 22 (Cuba).

*Triton brasilianum* Gould 1849, Proceedings Boston Society Natural History **3**, p. 142 (Rio de Janeiro, Brasil); Gould 1856, Appendix, p. 504 of the United States Exploring Expedition **12**, pl. 17, fig. 296.

*Monoplex australasiae* Perry 1811, Conchology, London, pl. 3, fig. 3 (New Holland and Lord Howe's Island).

*Triton (Simpulum) acclivis* Hutton 1873, Catalogue of the Marine Mollusca of New Zealand, Wellington, p. 13, fig. 8 (New Zealand).

**Description.** Shell large in size, reaching 145 mm. (about  $5\frac{3}{4}$  inches) in length, rather heavy in structure, imperforate or with a small umbilical chink and with a pronounced spiral sculpture. Color brownish yellow, usually fairly uniform, but occasionally with spiral bands of slightly darker brown which become much darker on the varices. Embryonic whorls three, smooth, light straw-yellow in color, extended and slightly tilted from the remaining whorls. Post-embryonic whorls 7 to 8, convex and slightly shouldered. Spire moderately extended and produced at an angle of about  $55^\circ$ . Aperture subelliptical, the outer lip margined within by coarse teeth which are grouped in pairs, occasionally having smaller secondary teeth. These palatal teeth are opposite the grooves which are between the spiral cords. Parietal wall with numerous, irregular, white plicae, the area between the plicae being a dark reddish brown. There is a single large ridge on the upper portion of the parietal wall which margins the anal canal. Siphonal canal somewhat variable and curved upward and slightly to the left when viewed dorsally. Columella thickened and continuing as the parietal margin of the siphonal canal. Suture slightly indented. Sculpture consisting of 5 or 6 broad, low and often nodulose, spiral cords, with numerous finer cords on the base and on the siphonal canal. In addition, there are numerous fine spiral threads which appear in the interspaces as well as on the cords themselves. Axial sculpture consisting of numerous fine growth lines. Varices rather low and usually with only two, including the lip, showing in fully grown adult specimens. Periostracum rather thin, a dark golden brown in color and produced in numerous axial blades with a hair-like fringe, and usually deciduous. Operculum unguiculate with a terminal nucleus and sculptured with numerous concentric growth lines.

<sup>1</sup> Parthenope was an old name for the town of Neapolis [Naples].

<sup>2</sup> We have seen only the English translation by Anthony Aufrere 1795, "Travels through various Provinces of the Kingdom of Naples in 1789," London, 527 pages, 9 plates.

length	width	
145 mm.	79 mm.	Bermuda
109	64	Nagasaki, Japan
96	56	Rio de Janeiro, Brasil
89	52.5	Moreton Bay, Queensland, Australia

*Types.* The type of *Murex costatus* Born is in the Zoological Museum, Vienna, Austria. The type of *Triton americanum* d'Orbigny is in the British Museum (Natural History). A paratype of *T. brasilianum* Gould is in the Museum of Comparative Zoology, no. 191179. We do not know the location of the type specimens of the other names listed in the synonymy. The type locality is Naples, Italy.

*Remarks.* The distribution of this species is quite remarkable, existing as it does in most tropical and warm temperate seas. On the basis of shell morphology we can detect no consistent differences in the specimens from any of the widely separated localities. This opinion was held by Watson (1886, p. 391) who reviewed most of the material con-

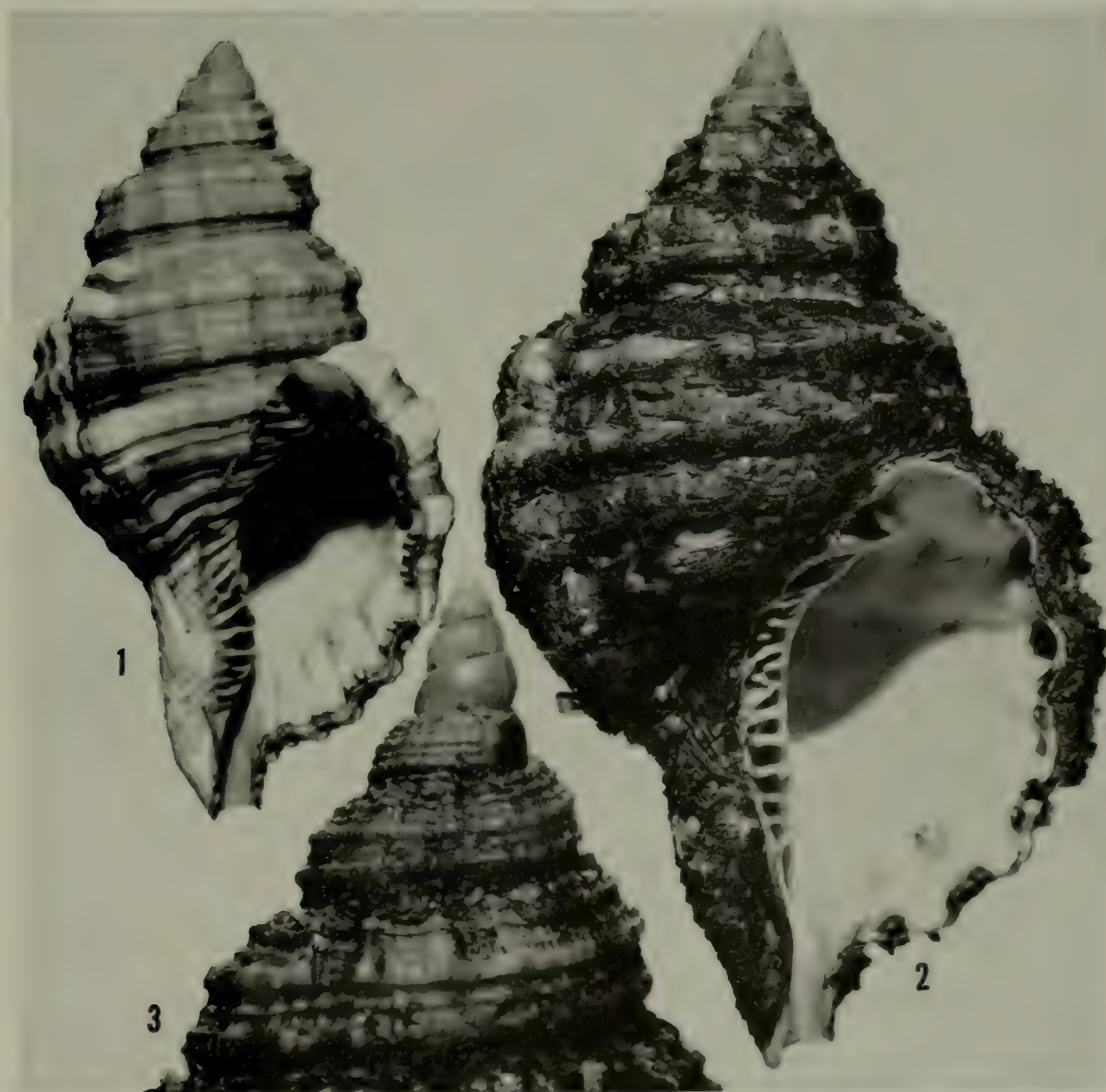


Plate 128. *Cymatium parthenopeum* von Salis. Fig. 1. Moreton Bay, Queensland, Australia (natural size). Fig. 2. Sanibel Island, Florida (natural size). Fig. 3. Rio de Janeiro, Brasil (to show embryonic whorls, 8x).

tained in several of the European museums. There may, of course, be consistent differences in the soft anatomy, but this study still remains to be done.

Our records are too few to determine whether or not there is a continuous population between the end localities in any one region. For example, Nicklès (1950, p. 86) states it occurs from Morocco and south to the Cape of Good Hope, but he neither lists any localities nor indicates upon how much material this statement was based. We possess material from Japan, Australia and New Zealand, but have no material from between these very widely separated localities. It is not known to occur in the Eastern Pacific.

The well-known name of *M. costatus* Born must give way to *C. parthenopeum* von Salis because of an earlier use of *Murex costatus* by Pennant in 1777 as indicated in the synonymy above. However, the name of von Salis has been used generally by Europeans for this species.

This species apparently is rarely found alive in the intertidal area, but it does occur from just below low water to depths of at least 35 fathoms.

De Gregorio (1884, Bullettino della Società Malacologica Italiana 10, p. 96) described two living and one fossil varieties of *parthenopeum* from Sicily.

*Range.* EASTERN ATLANTIC: Western Mediterranean, the Azores and south to the Union of South Africa.

WESTERN ATLANTIC: Bermuda, Florida and Mexico, the West Indies and south to Brasil.

INDO-PACIFIC: Japan, eastern Australia, northern New Zealand and Portuguese East Africa.

*Specimens examined.* FLORIDA: south end of Lake Worth; Jupiter Inlet, Palm Beach Co. (both FSM); Bear Cut, Key Biscayne (R. Work); Dry Tortugas (R. Merrill; FSM); Naples (MCZ); Sanibel Island (J. Schwengel); St. Andrews Bay, Panama City (R. Work). TEXAS: off Port Isabel in 25 fathoms (H. and K. Johnstone). MEXICO: off Laguna Madre, Tamaulipas in 32 to 35 fathoms (H. Hildebrand); 15 miles N of Tecolutla, Veraacruz (T. Pulley); Campeche (H. Hildebrand). BERMUDA: (MCZ). CUBA: Matanzas Bay and Varadero Beach, Matanzas (both J. Finlay). PUERTO RICO: Mona Island; Punta Algarrobo (both G. Warmke). VIRGIN ISLANDS: St. Thomas (ANSP); Tortola (MCZ; ANSP). LESSER ANTILLES: Barbados; Trinidad (both MCZ). BRASIL: Praia de Leste, Ilha Guaiba, Est. de Rio de Janeiro (de Oliveira); Rio de Janeiro (MCZ); Praia de Urca, Districto Federal; Manguinhos, Ilha de Itaparica, Est. de Bahia (both de Oliveira).

EASTERN ATLANTIC. FRANCE: Marseilles (MCZ). ITALY: Catania, Sicily (W. Old). ALGERIA: Gulf of Oran in 19 fathoms (MCZ). AZORES: Fayal (MCZ). SENEGAL: Dakar (MCZ). SOUTH AFRICA: Jeffreys Bay (D. H. Kennelly); Port Alfred (J. Schwengel).

INDO-PACIFIC. NEW ZEALAND: Lauranga Harbour; Hen and Chicken Reef (both MCZ); Pana, Parengarenga Harbour (A. W. B. Powell). AUSTRALIA: Moreton Bay, Queensland (MCZ; J. Schwengel); Narooma, New South Wales (MCZ); Sydney, New South Wales (J. Schwengel); Ulladulla, New South Wales (E. Grigg). JAPAN: Awaji; Kishiu; Misaki, Sagami; Yenosima; Tokyo Bay; Koka Shima (all MCZ); Nagasaki (ANSP). PORTUGUESE EAST AFRICA: Bazaruto Island, Bazaruto Bay (J. K. Howard).

Subgenus **Cymatium** *Röding*

*Cymatium* Röding 1798, Museum Boltenianum, p. 129.

Type species, *Murex femorale* Linné, subsequent designation, Dall 1904.

Shell large, triangular in cross section, and generally a rich golden brown in color. Sculpture consisting of large knobs and spiral cords, in addition to having three or more well-developed varices. Both palatal denticles and parietal plicae usually well-developed. Generally with a depressed area at the beginning of the siphonal canal. Siphonal canal usually extended and curved upwardly. Periostracum thin and slightly roughened over most of the surface, but producing high, thin, axial blades which are fringed. Operculum small for the size of the aperture, unguiculate, with a terminal nucleus and sculptured with rather coarse concentric ridges.

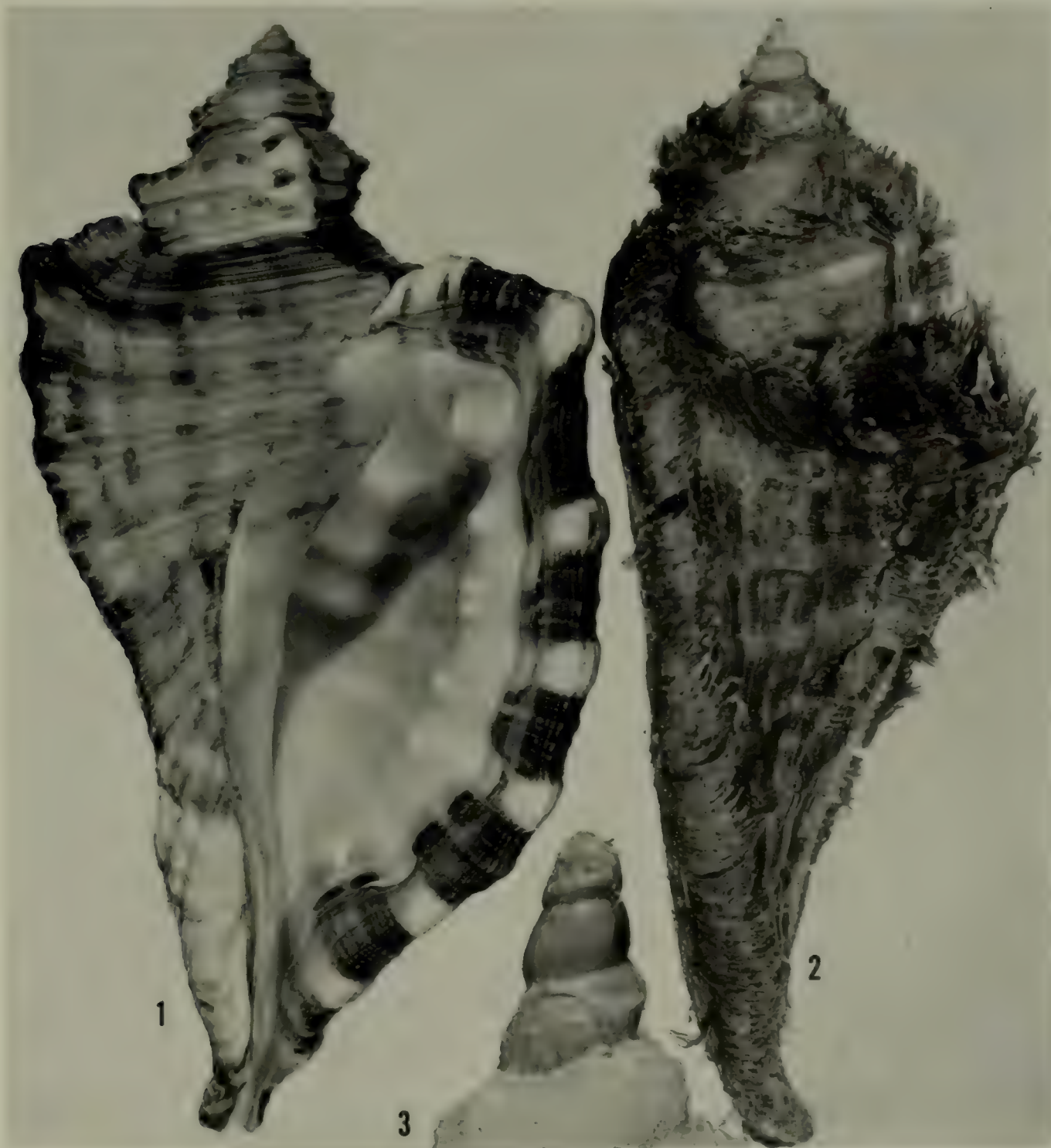


Plate 129. *Cymatium femorale* Linné. Fig. 1. Great Abaco, Bahama Islands (slightly reduced). Fig. 2. Bear Cut, Miami, Florida (slightly enlarged). Fig. 3. French Beach, Varadero, Matanzas, Cuba (to show embryonic whorls, 12.4x).

Only one member of this subgenus is found in the Western Atlantic, with a single species in the Eastern Pacific; the remaining few species are from the Indo-Pacific area.

### **Cymatium (Cymatium) femorale Linné**

Plate 110, fig. 1; Plate 112, figs. 9-10; Plate 113, fig. 11; Plate 129, figs. 1-3

*Murex femorale* Linné 1758, Systema Naturae, ed. 10, p. 749 (O. Asiatico); Hanley 1855, Ipsa Linnaei Conchylia, p. 287.

*Lotorium lotor* Montfort 1810, Conchyliologie Systématique 2, p. 583 (côtes d'Afrique).

*Septa triangularis* Perry 1811, Conchology, pl. 14, fig. 6 (Southern Ocean).

*Triton lotorium* Lamarck 1816, Tableau Encyclopédique et Méthodique, Liste, p. 5, Atlas 3, pl. 415, fig. 2.

**Description.** Shell large, reaching 220 mm. (about 8½ inches) in length, strong but not heavy, imperforate and sculptured. Color a golden brown to light reddish brown with alternating bands of brown and white on the varices. Whorls 8 or 9, convex, somewhat flattened dorso-ventrally and slightly shouldered. Spire somewhat extended. Aperture auricular in shape, the parietal wall consisting of a thin glaze; within there may be 1 to 4 or 5 small relatively inconspicuous plicae. Certain of these appear to be independently produced while others are nothing more than the glaze over the spiral cords. Outer lip rolled inwardly to form a varix. Columella irregular; it may be nearly straight or strongly arched inwardly and to the left. Siphonal canal somewhat extended and curved upwardly. Suture relatively indistinct. Sculpture consisting usually of five varices (lip included), visible in the adult. The varices are knobbed, the knobs being the high points where the spiral cords pass over them. There are 6 to 8 rather heavy, conspicuous spiral cords, the largest and heaviest at the shoulder. In addition, this shoulder cord may be irregularly nodulose and occasionally smaller nodules are present on the cords below the shoulder cord. Between the cords there are numerous spiral threads and these are crossed by somewhat finer axial threads. Operculum unguiculate and relatively small for the size of the aperture. It has a marginal nucleus and the growth ridges are concentrically developed. Periostracum thin, light but rough, somewhat foliated, yellowish brown in color and deciduous. Occasional specimens are found with several axial, fringed blades of periostracum which correspond with the axial ribs of the shell.

length	width	
212 mm.	115 mm.	Gulf of Mexico
176	74	Savannah Sound, Eleuthera Island, Bahama Islands
153	75	Cayo Francés, Caibarién, Las Villas, Cuba

**Types.** The holotype of *Murex femorale* Linné, according to Hanley (1855) is in the Linnean Collection of the Linnean Society, London. We here restrict the type locality to Jamaica, the locality given by Lister in his *Historiae Methodicae Conchyliorum* on plate 941 to which Linné referred.

**Remarks.** This is a species of rather wide distribution throughout the West Indian region. Specimens are not rare, yet they never appear to be common at any one locality. They are usually found a little beyond low water in areas with a sandy bottom where sea grass is abundant. Dall (1889, p. 132) has given Cedar Keys as the northern limit of this species on the west coast of Florida. This appears to be an error, however, as the species probably does not occur, at least alive, north of Key West on the west coast of Florida.

*Range.* Bermuda, southeastern Florida and the lower Florida Keys, throughout the West Indies, and from central Mexico south to Bahia, Brasil.

*Specimens examined.* FLORIDA: Melbourne, Brevard Co. (FSM); Bear Cut, Key Biscayne, Miami (R. Work; H. and K. Johnstone); Ragged Keys, Biscayne Bay (MCZ); Key West (ANSP; FSM); Tortugas (J. Miller). BERMUDA: Castle Harbour (dredged dead, H. B. Moore). BAHAMA ISLANDS: High Rock, Grand Bahama (MCZ); Elbow Cay, Great Abaco (G. Kline; R. Robertson); Nixon's Harbour, South Bimini, Bimini Islands; Hog Island, New Providence (both MCZ); Dick's Point, Nassau, New Providence (G. Kline); Spanish Wells, Eleuthera (MCZ; J. Schwengel); The Current, Eleuthera (G. and M. Kline); Sandy Point, Savannah Sound, Eleuthera; Little San Salvador; Orange Creek, Cat Island; Arthurs Town, Cat Island; Wemyss, Long Island; Matthew Town, Great Inagua (all MCZ). CUBA: near Habana (R. Humes); Cayo Francés, Caibarién, Las Villas (Museo Poey); Varadero, Cárdenas, Matanzas (ANSP; J. Finlay); Fishpoint, Guantánamo Bay (MCZ). HISPANIOLA: Cap Haïtien, Haiti (W. J. Eyerdam); Montecristi, Santo Domingo; Puerto Plata, Santo Domingo (both MCZ). JAMAICA: Whitehouse (J. K. Howard). PUERTO RICO: Cataño; Arecibo (both G. Warmke); Punta Borinquén (A. Phares); Rincón; Bahía de Añasco; Mayagüez; Ensenada; Puerto Patillas (all G. Warmke); Punta Guanajibo; Punta Algarrobo (both UPR). VIRGIN ISLANDS: Guana Island, Tortola (M. Dewey); St. Thomas (MCZ; ANSP); St. Johns (MCZ); St. Croix (FSM). LESSER ANTILLES: Barbados (MCZ; ANSP); English Harbour, Antigua (K. Anderson). CARIBBEAN ISLANDS: Oranjestad Harbour, Aruba (D. P. Barnes). MEXICO: Tampico, Tamaulipas; 15 miles N of Tecolutla, Veracruz (both T. Pulley). NICARAGUA: Bluefields (MCZ). PANAMA: Panama (Atlantic) (MCZ). BRASIL: Itapagipe, Salvador, Bahia (H. L. Lopes).

### **Cymatium (Cymatium) tigrinum Broderip**

Plate 130, figs. 1-2

*Triton tigrinus* Broderip 1833, Proceedings Zoological Society London, p. 5 (in America Centrali (Guacomayo)).

*Description.* Shell large, reaching 185 mm. (about  $7\frac{1}{2}$  inches) in length, strong and fairly heavy, imperforate and sculptured. Color a light reddish brown to yellow, overlaid by a rather dark reddish brown, roughened periostracum. Varices dark brownish red between the spiral cords. This color is also present inside the outer lip. Base of the columella may also be stained a dark mahogany-brown. Whorls 8 to  $8\frac{1}{2}$ , convex and flattened dorso-ventrally. Spire extended. Aperture subelliptical. Outer lip thickened when the heavy varix is present. Inner lip consisting of a somewhat heavy glaze on the parietal area. Outer lip rolled inwardly to form a varix. Columella straight to slightly curved. Siphonal canal somewhat extended and curved upwardly. Sculpture consisting usually of five varices (lip included) which are visible in the adult. These varices are doubled in all specimens which we have seen, except for the last varix. The varices are knobbed, the knobs being the high points where the spiral cords pass over the varices. There are 8 or 9 conspicuous spiral cords; the largest may possess 1 or 2 rather large nodules. In between the cords there are numerous and relatively indistinct spiral threads. Apical sculpture consisting mainly of very fine growth lines. Periostracum rather heavy, roughened, particularly at the varices and deciduous. Operculum unknown.

length	width	
185 mm.	101 mm.	Acapulco, Mexico
164	86	Corinto, Nicaragua
111	65	Panama

*Types.* The holotype of *T. tigrinus* Broderip is probably in the British Museum (Natural History). The type locality is Guacomayo, Central America. We have been unable to locate any coastal village by this name.

*Remarks.* This is a very distinct species and apparently not closely related to any other known species. We have added it here only as representing the Eastern Pacific analogue of the Western Atlantic *C. femorale*. The two species, however, are not closely related.

This appears to be a very rare species to judge by the few specimens that are to be found in our museums. The range we give below is probably not the limitations of this species. It may very well extend south at least to northern Ecuador.

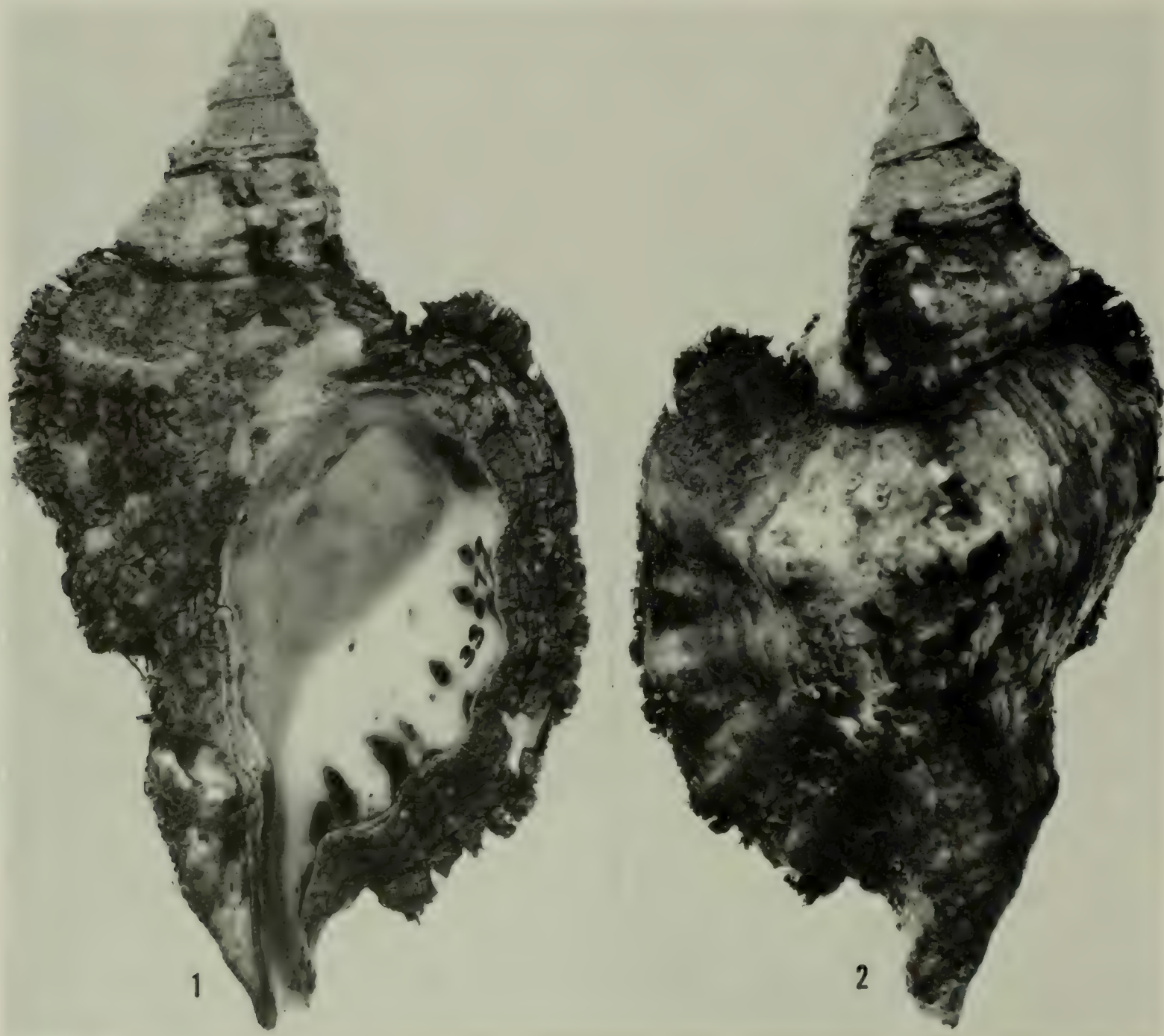


Plate 130. *Cymatium tigrinum* Broderip. Figs. 1-2. Costa Rica. (California Academy of Sciences, no. 33079, natural size.) Photograph through the kindness of Dr. L. G. Hertlein.

*Range.* From La Paz, Baja California (Pilsbry and Lowe 1932) south to Panama.

*Specimens examined.* MEXICO: Acapulco (MCZ; San Diego Soc. Nat. Hist.): Est. Oaxaca (Stanford Univ.). NICARAGUA: Corinto (San Diego Soc. Nat. Hist.). COSTA RICA: (California Acad. Science; USNM). PANAMA: (MCZ; ANSP; USNM). Venado Island (J. Schwengel; Mrs. J. D. Elliott); Balboa, Canal Zone (W. Old).

### Genus *Distorsio* Röding

*Distorsio* Röding 1798, Museum Boltenianum, p. 133.

*Distortrix* Link 1807, Beschreibung der Naturalien-Sammlung der Universität zu Rostock, p. 122 (type species, *Distortrix anus* Linné [= *Murex anus* Linné], subsequent designation, Dall 1904).

*Persona* Denys de Montfort 1810, Conchyliologie Systématique 2, p. 603 (type species, *Persona anus* Linné [= *Murex anus* Linné], monotypic).

*Distorta* Perry 1811, Conchology, pl. 10, fig. 2 (type species, *Distorta rotunda* Perry [= *Murex anus* Linné], subsequent designation, Puffer and Emerson 1953).

*Distortio* 'Bolten' Gray 1847, Proceedings Zoological Society London, p. 133 [correction for *Distorsio* Röding].

*Distortix* 'Link' Paetel 1875, Familien- und Gattungsnamen der Mollusken, Berlin, p. 71 [error for *Distortrix* Link].

*Persoma* 'Montfort' Paetel 1875, Familien- und Gattungsnamen der Mollusken, Berlin, p. 157 [error for *Persona* Montfort].

*Distorsus* 'Bolten' Paetel 1888, Catalog der Conchylien-Sammlung 1, p. 103 [error for *Distorsio* Röding].

*Distorsia* 'Röding' Pilsbry 1922, Proceedings Academy Natural Sciences 73, p. 359 [error for *Distorsio* Röding].

Type species, *Murex anus* Linné, subsequent designation, J. E. Gray 1847.

Winckworth in 1945 apparently overlooked Gray's type designation for this genus in 1847. Even though Gray corrected the spelling to *Distortio* there is no question that he was referring to *Distorsio* 'Bolten' Röding. Pilsbry (1922) has been credited with the type designation.

Shell ranging from 25 mm. (1 inch) to 75 mm. (about 3 inches) in length, imperforate, subglobose to elongate, and rather solid in structure. Color ranging from a grayish white to mottled brown. Whorls very irregular and distorted. Sculpture consisting of spiral cords and axial costae. Parietal shields thin but extended and portions of previous shields remain on earlier whorls producing the varices. Aperture auricular in appearance being complicated by numerous palatal denticles and parietal plicae. The denticles and plicae produced at earlier stages of growth are not absorbed as the shell grows but remain as internal structures in the shell as shown in Plate 131. Because of this apertural armature the shell is twisted and bulges to compensate for the space occupied by these internal denticulations.

Species in this genus are found in most tropical portions of the world and range from low water to depths of about 300 fathoms. According to Woodring (1928, p. 299) the earliest *Distorsio* s.s. appeared in the Byram marl, Upper Oligocene of Mississippi.

Some of our recent species are exceedingly close, if not identical with certain fossil forms. This is particularly true of *D. mcgintyi* Emerson and Puffer, and *D. decussatus simillimus* Sowerby as figured by Woodring (1928, plate 18, fig. 9 and plate 19, fig. 1). The other specimens figured by Woodring (plate 18, figs. 7-8) appear to be *clathrata* Lamarck.

The opercula of all species so far examined are quite irregular, small for the size of the shell and often broken, undoubtedly a result of the great irregularity of the aperture. The nucleus of the operculum is submarginal. The general proportions and shape of the operculum and the muscle scars appear to be quite variable as shown on plate 132.

The radula is taenioglossate with a relatively small central tooth, a broad and denticulate lateral tooth and two subequal marginal teeth.

### Subgenus **Distorsio** Röding

*Distorsio* Röding 1798, Museum Boltenianum, p. 133.

Type species, *M. anus* Linné, subsequent designation Gray 1847.

This subgenus contains but a single species and is characterized by the shell producing an exceedingly large parietal shield which extends well above the upper limits of the outer lip and covers the two preceding whorls. The early shields are not absorbed but remain as thin blade-like varices. Siphonal canal is nearly vertical and not visible from the apertural side.

*Distorsio anus* Linné, the only species now known to belong in the subgenus *Distorsio*, is wide-ranging throughout most of the tropical Indo-Pacific.

### Subgenus **Rhysema**,<sup>1</sup> new subgenus

Shell ranging in size from 25 mm. (1 inch) to 90 mm. (about 3½ inches). Color ranging from grayish white or light yellow to pinkish. Parietal shield broad but not extending above the upper limit of the outer lip. Sculpture consisting of spiral cords and axial costae, both being about equal in coarseness. Siphonal canal curved upwards but not vertical.

This subgenus differs from typical *Distorsio* by lacking the extended parietal shield and by not having the siphonal canal vertical.

Species in this subgenus occur in nearly all tropical and subtropical seas.

Type species, *Triton clathratus* Lamarck.

### **Distorsio (Rhysema) clathrata** Lamarck

Plates 131; 132, figs. 2-8; 133

*Triton clathratum* Lamarck 1816, Tableau Encyclopédique et Méthodique, Liste, p. 4, Atlas 3, pl. 413, fig. 4a-b; Lamarck 1822, Animaux sans Vertèbres 7, p. 186 [reference to the Tableau only] (mers de l'Amérique Méridionale).

*Distortrix reticulata* 'Link' Dall 1889, Bulletin Museum Comparative Zoology 18, p. 221 [in part]; non *D. reticulata* Link 1807 [= *D. reticulata* Röding 1798].

**Description.** Shell medium in size, reaching 77 mm. (about 3 inches) in length, rather solid, imperforate and strongly sculptured. Color white with a diffusion of yellowish or pinkish brown. Whorls 10, convex and irregular. Spire extended and produced at an angle of about 45°. Aperture auricular in shape, the outer lip being somewhat thickened and with 10 denticles, the third below the anal canal being the largest, while the smallest

<sup>1</sup> From the Greek, wrinkle; pucker.

one margins the siphonal canal. The largest denticle is opposite the deep parietal embayment. Inner lip consisting of numerous plicae. There are two large parietal plicae which margin the anal canal. On the lower portion of the columellar area there are 13 or 14 plicae. These are smallest near the siphonal canal, becoming larger posteriorly and project outward to form the anterior margin of the parietal embayment. In the parietal embayment the spiral cords are slightly thickened. A thin parietal shield is developed which is margined on the parietal side by glazing over the back of the thin varix and continuing as a ridge both above on the upper portion of the whorl and below to the mid area of the siphonal canal. Columella nearly straight but complicated by the numerous plicae. These plicae follow back to the early whorls. The denticles which were produced on early lips are not absorbed but remain within the shell as shown in Plate 131. Siphonal canal moderately short and narrow, deflected slightly toward the outer lip and turned slightly upward. Anal canal formed by the uppermost palatal denticle and the two parietal plicae. Suture slightly impressed, irregular and occasionally obscure. Spiral sculpture consisting of numerous cords interspaced with numerous and very fine spiral threads. Axial sculpture consisting of numerous ridges which cross the spiral cords to form a reticulated pattern. Where the spiral cords and axial ridges cross they produce small knobs. There are 7 to 9 varices. Operculum small for the size of the shell due to the distorted aperture. It is unguiculate in shape, has a submarginal nucleus and is sculptured with numerous concentric growth lines. Periostracum thin, yellowish brown in color, finely reticulate, and having numerous, fine hair-like processes over the entire surface and coarse hair-like processes on the knobs. The embryonic shell has 3 whorls which are smooth, glass-like in appearance and light amber in color.

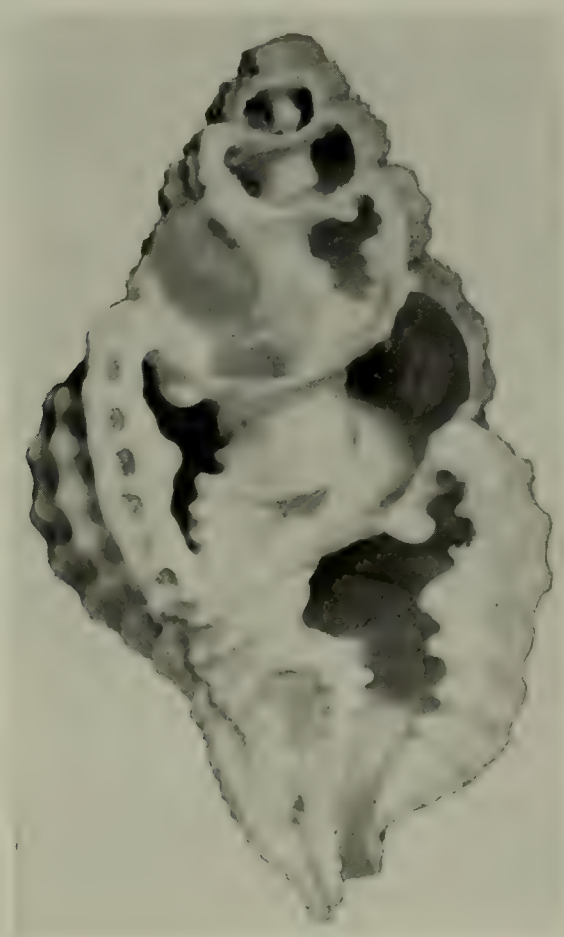


Plate 131. *Distorsio clathrata* Lamarck, Tuxpan, Veracruz, Mexico (1.5x). A sectioned shell to show retention of the early varices and apertural armature.

length	width	
77 mm.	43 mm.	off Key West, Florida
70	38	Bahía de Campeche, Mexico
67	34	West of Tortugas, Florida
62	34	Puerto Plata, Santo Domingo

*Types.* The present location of the holotype of *Distorsio clathrata* Lamarck is unknown to us. It is probably in the Paris Museum. The type locality as given by Lamarck

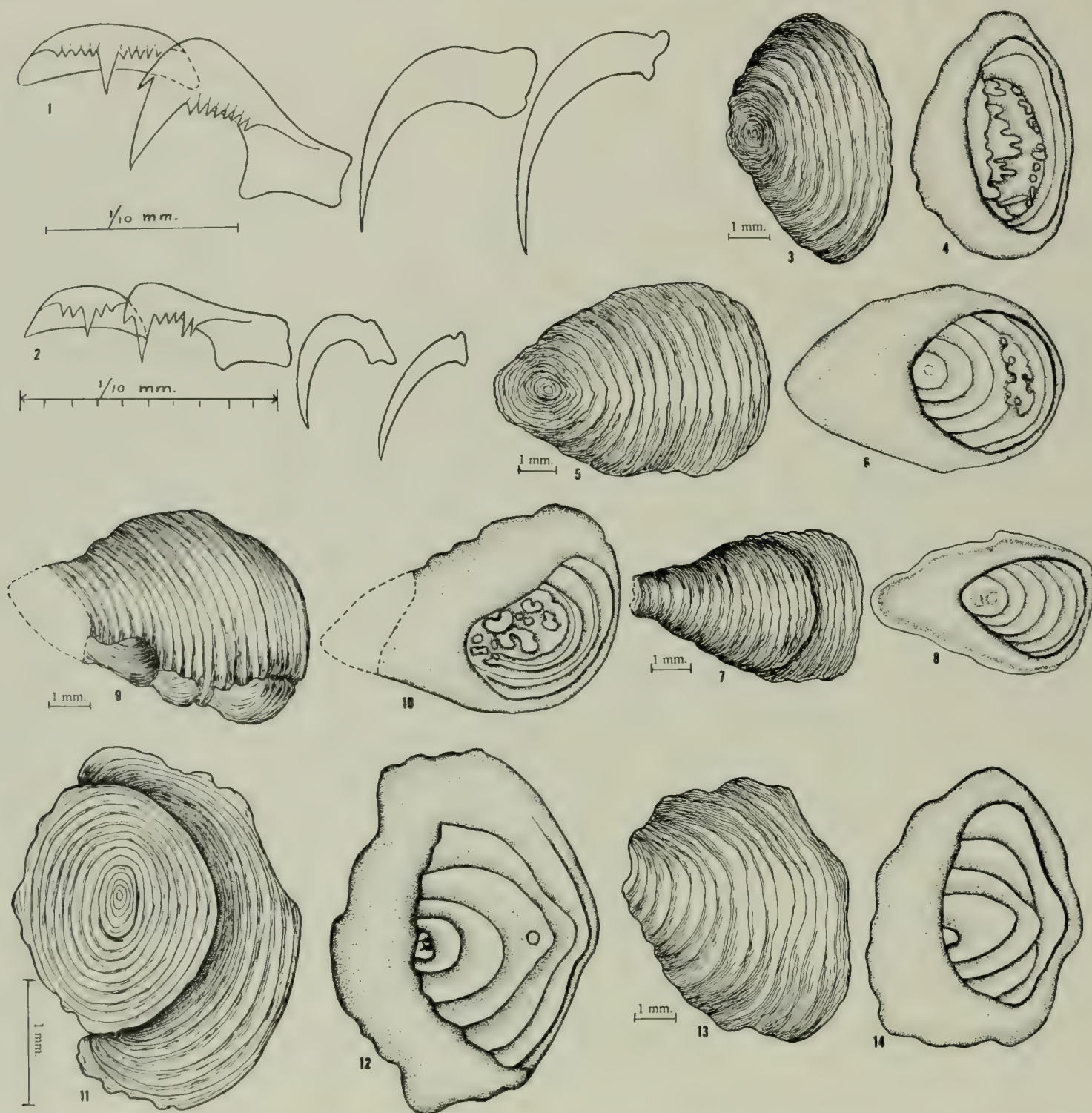


Plate 132. Radulae and opercula of *Distorsio*. Fig. 1. Radula of *Distorsio anus* Linné, Amboyna, Molucca Islands. Fig. 2. Radula of *Distorsio clathrata* Lamarck, Punta Algarrobo, Puerto Rico. Figs. 3-4. Operculum of *Distorsio clathrata* Lamarck from the same locality. Figs. 5-6. *Distorsio clathrata* Lamarck, 20 miles NE of North Pass, Mississippi Delta in 100 fathoms. Figs. 7-8. *Distorsio clathrata* Lamarck, SW of Destin, Florida in 18 to 20 fathoms. Figs. 9-10. *Distorsio mcgintyi* Emerson and Puffer, SSW of Sombrero Key, Key Vaca, Florida. Figs. 11-12. *Distorsio anus* Linné, Pwakuu Island, West Zanzibar in 11 to 18 fathoms, a young and broken operculum. Figs. 13-14. *Distorsio anus* Linné, Amboyna, Molucca Islands.

is "mers de l'Amérique Méridionale." We here restrict the type locality to the Bay of Campeche, Mexico, an area from which Lamarck had received much material.

*Remarks.* The two species in this genus found in the Western Atlantic are quite easily differentiated. The adult specimens of *D. clathrata* are nearly twice as large as those of *D. mcgintyi*. In addition, *D. clathrata* has two parietal plicae near the siphonal canal while there is only one in *mcgintyi*. There are 13 or 14 columellar plicae which extend well down the siphonal canal in *D. clathrata* but only 9 in *mcgintyi* and these stop abruptly about half way down the siphonal canal. In fully adult specimens of *D. mcgintyi* one of the spiral cords becomes thickened and forms a plica in the center of the parietal embayment. There is only a slight thickening of the spiral cords in this area in *D. clathrata*. The irregular coiling of the whorls is far more accentuated in *D. mcgintyi* than in *clathrata* and the siphonal canal is much shorter.

Dall in 1889 (loc. cit.) was the first to note that there were two different forms of *Distorsio* in the Western Atlantic. However, these were not named as new but considered varieties of his *reticulata*, a name now applied to an Indo-Pacific species. Olsson and McGinty first described the deeper water form as *Distorsio constricta floridana* but unfortunately the name *floridana* was preoccupied and so it was renamed *mcgintyi* by Emerson and Puffer.

*Distorsio clathrata* Lamarck is generally found from just below low water to depths of about 30 fathoms though we have examined two lots supposedly taken from depths of about 100 fathoms.

*Range.* From Cape Hatteras, North Carolina (Dall 1889, Bulletin United States National Museum, no. 37, p. 132) where it occurs occasionally and from Lake Worth, Florida, the northern Gulf of Mexico south to British Guiana. It is found throughout the West Indies.

*Specimens examined.* FLORIDA: South Inlet, Lake Worth (MCZ; ANSP); Lake Worth, Boynton (T. McGinty); off Palm Beach in 20 fathoms (ANSP); off Sombrero Key, Key Vaca in 30 to 60 fathoms (MCZ; ANSP); off Key West in 17 fathoms (H. and K. Johnstone); W of Dry Tortugas in 10 to 12 fathoms (J. S. Schwengel); 30 miles NE of Dry Tortugas (ANSP); 18 miles SW of Destin in 18 to 20 fathoms (T. McGinty); off Fort Walton in 20 fathoms (MCZ). ALABAMA: 20 miles off Petit Bois Island in 10 fathoms; 45 miles off Bayou La Batre (both H. and K. Johnstone); MISSISSIPPI: 2 to 3 miles off Horn Island in 12 to 14 fathoms (H. and K. Johnstone). LOUISIANA: 20 miles NE of North Pass, Mississippi Delta in 100 fathoms; off Pass Saluda Light (both H. and K. Johnstone). TEXAS: off Aransas Pass (ANSP); Mustang Island (J. W. Hedgpeth); off Port Isabel (L. A. Weisenhaus); SE of Pass Cavallo and E of St. Joseph Island (both H. Hildebrand); Brownsville (ANSP). BAHAMA ISLANDS: Bullocks Harbour, Great Harbour Cay, Berry Islands (G. and M. Kline). CUBA: Matanzas Bay, Matanzas (C. J. Finlay). HISPANIOLA: Puerto Plata, Santo Domingo (MCZ). PUERTO RICO: Aguadilla (A. Phares); Bahía de Añasco (MCZ); Punta Algarrobo; Mayagüez (both G. L. Warmke). VIRGIN ISLANDS: St. Thomas (ANSP). MEXICO: Bahía de Campeche (MCZ; Museo Poey; H. and K. Johnstone); Veracruz, Veracruz (ANSP; M. E. Bourgeois); Tuxpan, Veracruz (M. E. Bourgeois); Tampico, Tamaulipas (T. Pulley);

Isla Mujeres, Yucatan (C. G. Aguayo): Punta Frontera, Tabasco (ANSP). PANAMA: 2 miles off Colón (W. J. Clarke). COLOMBIA: Cartagena (MCZ). VENEZUELA: Guanta (ANSP). BRITISH GUIANA: 4 miles E of Georgetown (H. G. Kugler).



Plate 133. *Distorsio clathrata* Lamarck. Figs. 1 and 3. West of Dry Tortugas, Florida in 10 to 20 fathoms (1.3x). Fig. 2. Boynton, Lake Worth, Florida (1.3x). Fig. 4. Off Fort Walton, Florida in 13 to 19 fathoms, showing embryonic whorls (18x).

### *Distorsio* (*Rhysema*) *mcgintyi* Emerson and Puffer

Plates 132, figs. 9-10; 134

*Distortrix reticulata* var. *clathrata* 'Lamarck' Dall 1889, Bulletin Museum Comparative Zoology **18**, pp. 221-222 (Lesser Antilles); non *clathrata* Lamarck 1816.

*Distorsio constricta floridana* Olsson and McGinty 1951, Nautilus **65**, p. 27, pl. 1, figs. 5, 6, 9 (off Palm Beach, Florida, in 30-40 fathoms); non *D. floridana* Gardner 1947 (Miocene).

*Distorsio mcgintyi* Emerson and Puffer 1953, Proceedings Biological Society of Washington **66**, p. 101 [new name for *D. constricta floridana* Olsson and McGinty 1951; non Gardner 1947].

**Description.** Shell small to medium in size, reaching 46 mm. (about  $1\frac{3}{4}$  inches) in length, solid, imperforate and strongly sculptured. Color white to pale yellowish brown. Whorls 9 to 10, convex and irregular. Spire moderately extended and produced at an angle of about  $45^\circ$ . Aperture auricular in shape, the outer lip somewhat thickened and with 8 or 9 denticles, the third below the anal canal being the largest, while the smallest one margins the anal canal. The largest denticle is opposite the deep parietal embayment. Inner lip consisting of numerous plicae. There is a single large plica margining the anal canal. On the lower portion of the columella area there are 9 plicae which are smallest near the siphonal canal, becoming larger posteriorly and projecting outward to form the anterior margin of the parietal embayment. In the center of the parietal embayment there is a single large plica which is developed upon one of the spiral ridges. A

thin parietal shield is developed which is free at its parietal margin and curved away from the shell. Columella nearly straight but complicated by the numerous plicae which continue back to the early whorls. Siphonal canal short, curved upwardly and toward the outer lip. Anal canal formed by the palatal denticle and the single parietal plica. Suture slightly impressed, irregular and occasionally obscure. Spiral sculpture consisting of numerous cords interspaced with numerous and very fine spiral threads. Axial sculpture consisting of numerous ridges which cross the spiral cords forming a reticulated pattern. In many specimens the axial ridges are more prominent. Where the spiral cords and axial ridges cross each other, small knobs are produced. There are 5 or 6 varices. Periostracum thin, yellowish brown in color, finely reticulate, having numerous very fine hair-like processes over the entire surface with a single large periostracal hair on each knob. Embryonic shell having 3 whorls which are smooth, glass-like in appearance and light amber in color. Operculum small for the size of the shell, unguiculate in shape, probably with a submarginal nucleus, and sculptured with concentric growth lines.

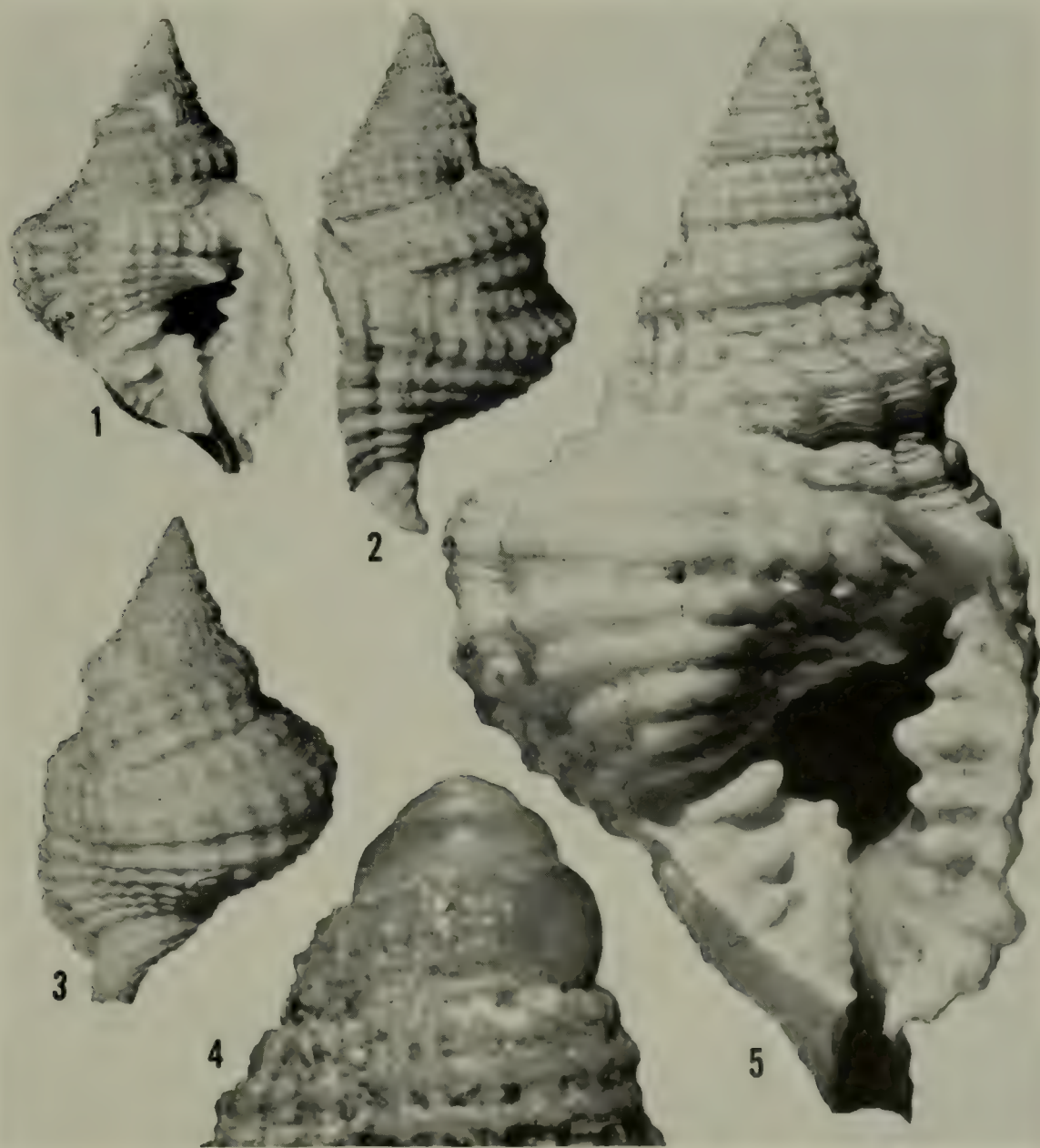


Plate 134. *Distorsio mcgintyi* Emerson and Puffer. Fig. 1. SW of Sombrero Light, Sombrero Key, Florida (1.3x). Fig. 2. Off Barbados, Lesser Antilles, *Hassler* voyage in 100 fathoms (1.3x). Fig. 3. Off Barbados, Lesser Antilles, *Blake* voyage in 82 fathoms (1.3x). Fig. 4. Off Barbados, Lesser Antilles, *Blake* voyage in 100 fathoms, showing embryonic whorls (16x). Fig. 5. Holotype of *Distorsio floridana* Olsson and McGinty (= *D. mcgintyi* Emerson and Puffer), off Palm Beach, Florida in 30 to 40 fathoms (4.4x).

length	width	
46 mm.	27 mm.	Off Barbados in 100 fathoms ( <i>Hassler Voyage</i> )
43	26	Off Barbados in 82 fathoms ( <i>Blake Voyage</i> )
32.5	20	Off Key Vaca, Florida in 70 fathoms
27.8	15.5	Holotype of <i>D. constricta floridana</i> Olsson and McGinty

*Types.* The holotype of *D. constricta floridana* Olsson and McGinty [= *D. mcgintyi* Emerson and Puffer] is in the Academy of Natural Sciences Philadelphia, no. 187684. The type locality is "Off Palm Beach, Florida in 30 to 40 fathoms."

*Remarks.* See *Remarks* under *D. clathrata* Lamarck. This is a deep water species, having been taken in depths of 30 to about 200 fathoms. It is most closely related to *D. constricta* Broderip of the Eastern Pacific from which it differs by having a pronounced plica in the parietal embayment and only a single parietal plica at the anal canal. In *constricta* the plica in the parietal embayment is small or wanting and there may be two or more plicae on the parietal wall at the anal canal. Both species are very irregularly coiled and otherwise quite similar.

*Range.* From off Palm Beach, Florida, the Florida Keys and south through the West Indies to the Island of Barbados.

*Specimens examined.* FLORIDA: off Palm Beach in 30, 40, 58 and 70 fathoms (T. McGinty; MCZ; ANSP);  $3\frac{1}{2}$  miles NE of Pacific Reef off Elliott Key in 66 fathoms (MCZ); off Carysfort Light, Key Largo (MCZ);  $5\frac{1}{2}$  miles SE of The Elbow, Key Largo in 66 fathoms (MCZ); off Sombrero Light, Key Vaca in 40 fathoms (T. McGinty; MCZ; ANSP); off Key Vaca in 70 fathoms (T. McGinty); off Pensacola in 45 fathoms (ANSP). CUBA: Bahía de Matanzas, Matanzas in 120 fathoms (C. J. Finlay). LESSER ANTILLES: off Guadeloupe, *Blake* Station 164 in 150 fathoms; off Dominica, *Blake* Station 177, in 118 fathoms; off Barbados, *Blake* Station 273, in 103 fathoms; off Barbados, *Hassler* Stations in 82 and 100 fathoms; off Grenada, *Blake* Station 247 in 170 fathoms; off Grenada, *Blake* Station 262 in 92 fathoms (all MCZ).

\* \* \* \*

### Notes

Under *Cymatium caribbaeum* Clench and Turner (p. 206) we discussed the confusion of names that existed for *cynocephalum* Lamarck and *cingulatum* Lamarck. The following is at least a partial list of the synonyms of *cynocephalum* in the Eastern Pacific. This species appears to be closely related to *C. poulsenii* Mörch of the Western Atlantic.

### *Cymatium cynocephalum* Lamarck

Plate 135, figs. 1-2

*Triton cynocephalum* Lamarck 1816, Tableau Encyclopédique et Méthodique, Liste, p. 5; Atlas, 3, pl. 422, fig. 3; Lamarck 1822, Histoire Naturelle des Animaux sans Vertèbres 7, p. 184 (locality unknown); non *Triton cynocephalum* 'Lamarck' Kiener 1842, and of subsequent authors.

*Cassidaria cingulata* Lamarck 1822, Animaux sans Vertèbres 7, p. 216 (no locality given).

*Fusus wiegmanni* Anton 1839, Verzeichniss der Conchylien, p. 77 (no locality given).

*Triton undosum* Kiener 1842, Iconographie des Coquilles Vivantes 7, Triton, p. 44, pl. 6, fig. 2 (locality unknown) [substitute name for *Cassidaria cingulata* Lamarck 1822].

*Triton chemnitzii* 'Gray' Reeve 1844, Conchologia Iconica 2, Triton, pl. 11, fig. 37 (Panama); non *Triton chemnitzii* Gray 1839.

*Cassidaria setosa* 'Hinds' Reeve 1844, Conchologia Iconica, 2, Triton, pl. 11, fig. 37 [nomen nudum, in the synonymy of *Triton chemnitzii* Reeve].

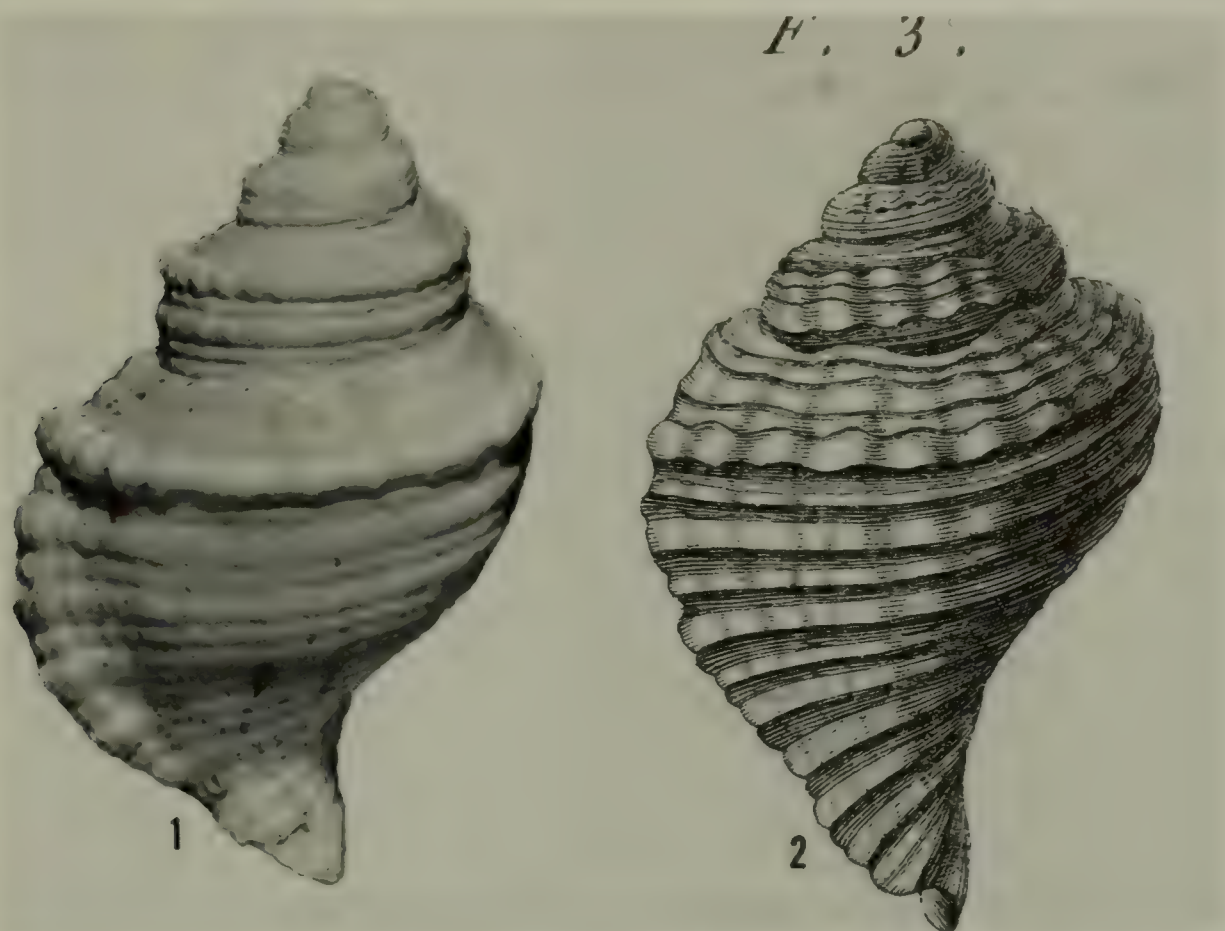


Plate 135. *Cymatium cynocephalum* Lamarck. Fig. 1. Bahía Magdalena, Baja California, Mexico (slightly enlarged). Fig. 2. From Lamarck's original figure, 1816, Tableau Encyclopédique et Méthodique, Atlas 3, pl. 422, fig. 3, Liste, p. 5.

\* \* \* \*

### A nomen nudum

*Cymatium* (*Ranularia*) *mohorteri* 'Verrill' Salisbury 1954, Zoological Record 89, sec. 9, p. 70 [nomen nudum].

This species was described in mimeographed form only.

\* \* \* \*

### The Genus *Bailya* M. Smith

In 1944 (Panamic Marine Shells, p. 22), Maxwell Smith instituted the genus *Bailya* as a new genus in the family Cymatiidae. He included in this genus *Triton parvus* C. B. Adams. Unfortunately he had overlooked a previous publication by Pilsbry and Vanatta (1904) in which *T. parvus* C. B. Adams, on the basis of its soft anatomy, was considered to be a species in *Tritonidea*, subgenus *Caducifer*, which is in the Family Buccinidae.

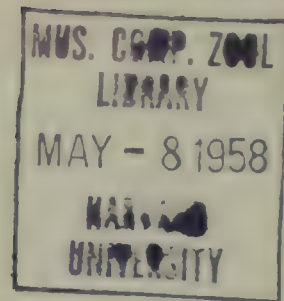
This in no way invalidates *Bailya*, as the type species is *Triton anomalus* Hinds, an Eastern Pacific species. Until the soft anatomy of this species is examined, the exact position of *Bailya* will remain unknown.

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PHASIANELLIDAE

VOL. 3. NO. 37

## THE FAMILY PHASIANELLIDAE IN THE WESTERN ATLANTIC

BY  
ROBERT ROBERTSON

The Phasianellidae is a family of gastropods found in shallow water in most tropical and temperate seas. The shells are often small and are usually conspicuously colored and patterned. The largest species live in the Australasian region.

The oldest fossil phasianellids are found in European Paleocene deposits (Cossmann 1918). Reports of Cretaceous species are dubious. Like most families of marine mollusks which differentiated in early Tertiary times, the group probably arose in Europe. The European Eocene (Tethyan) marine mollusk fauna not only was in large part ancestral to the modern Indo-Pacific fauna (see in particular Davies 1934) but also to the modern Caribbean and Panamic faunas. The Phasianellidae were derived from a trochacean stock and from Europe they spread around the world by way of the Tethyan Sea. Numerous late Tertiary species have been described.



Plate 136. *Phasianella australis* Gmelin. Semaphore, near Port Adelaide, South Australia (1.5x). The type species of *Phasianella* Lamarck.

The shell is entirely porcellaneous; in the most closely related families, the Turbinidae and Trochidae, it is invariably nacreous within. Both in the Phasianellidae and the Turbinidae the operculum is calcareous and usually paucispiral, while in the Trochidae it is always multispiral and corneous. The Phasianellidae differs from the Turbinidae and Trochidae also in that the shells are usually smooth and bulimoid in shape rather than turbate or trochoid. All three families belong in the superfamily Trochacea, which, in turn, is grouped in the order Archaeogastropoda, the most primitive living gastropods. Most families in this order have a rhipidoglossate radula, that is, have numerous marginal teeth (the only exception is in the superfamily Patellacea—the true limpets). Primitively, archaeogastropods have a pair of ctenidia ("gills"), but the Trochacea is one of the more advanced groups in which one ctenidium (the one on the right side) has been lost as a result of the long term effects of asymmetrical coiling.

Phasianellid radulae have been studied by Troschel (1878), Pilsbry (1888), Torr (1914), Thiele (1924, 1929), Kuroda and Habe (1954) and Habe (1956). During the present study the radulae of twenty species in the family were examined. Nine of these are type species of supraspecific taxa. Material was not available of the types of the two remaining groups based on Recent species (*Pellax* Finlay and *Gabrielona* Iredale). All six Western Atlantic species were examined.

There are four main kinds of phasianellid radulae. These correlate fairly well with shell form and are here considered indicative of natural groups. Only two of these groups live in the Western Atlantic.

In *Phasianella* Lamarek the central tooth of the radula is needlelike; often it is absent along parts of the length of a ribbon. There are five pairs of laterals and each has an elongate longitudinal attachment. Each transverse row of laterals is fairly straight (Plate 138, fig. 1). The complicated way in which the inner marginals fit into one another is well described and figured by Torr (1914). This group lives from the Red Sea to New Caledonia, north to Japan and south to Tasmania.

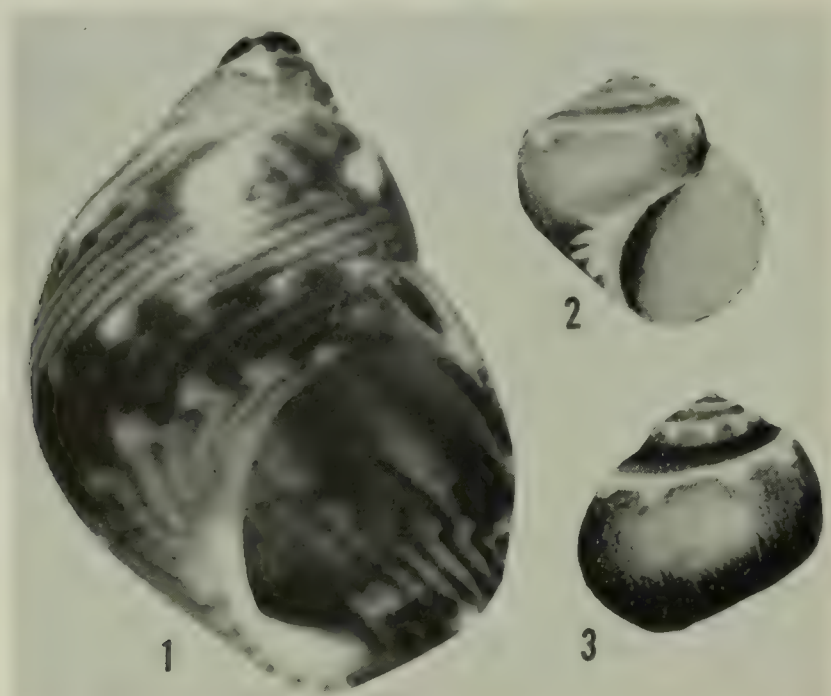


Plate 137. Fig. 1. *Tricolia pullus* Linné. St. Lunaire, near St. Malo, Ille et Vilaine, France (13.5x). The type species of *Tricolia* Risso. Figs. 2-3. *Gabrielona nepeanensis* Gatliff and Gabriel. Point Nepean and Flinders, Victoria, Australia (15x). The type species of *Gabrielona* Iredale. From Gatliff and Gabriel 1908, pl. 21, figs. 9-10.

In *Gabrielona* the central tooth is large, with an entire cusp, and its attachment to the ribbon is neatly fitted between the innermost pair of laterals. There are five pairs of laterals and the transverse rows are fairly straight. The second marginal is large (Plate 138, fig. 2). This group is little known and the description and figure are based on a West Indian species which is here referred to this genus on the basis of shell characters. The type species, *Phasianella nepeanensis* Gatliff and Gabriel, is Australian.

In the third group, which includes *Hiloe* Pilsbry, *Eotricolia* Kuroda and Habe and probably *Pellax*, free laterals are reduced in number to two or three pairs, each with a 'hood.' There is a cusped pseudocentral tooth made up of the reduced central which is fused with the innermost pair of laterals. The median tooth of *Eotricolia* is considered a true central by Kuroda and Habe (1954) and the three innermost pairs of marginals are incorrectly considered laterals. Through comparisons with *Hiloe* it seems almost certain that the median tooth of *Eotricolia* is a pseudocentral rather than a true central. Thiele's description (1929) of the radula of *Eulithidium* Pilsbry is based incorrectly on a species in this group, which is known at present only from Hawaii, Australia and Japan.

In the fourth and largest group, *Tricolia* Risso, s.s., the central tooth is large, membranous, without cusps and variable in shape, even along the length of a single radula. It is usually oval or rectangular. In all species examined there is a structure without cusps, most easily seen through the ribbon, which lies between the outermost longitudinal row of laterals and the innermost row of marginals, usually between the transverse rows. The name lateromarginal plate is here suggested for it. Its function is problematical and it appears not to have been previously described. The transverse rows of laterals are M-shaped. All six European, African and western Indo-Pacific species so far studied have five pairs of laterals (Plate 138, fig. 3). All the American species have four.<sup>1</sup> In the three Eastern Pacific species of *Tricolia* so far studied the innermost laterals are elongate, winged laterally at the anterior end and lie close together beneath the central, with the posterior part of the cusp projecting slightly over the central (Plate 138, figs. 4, 6). The cusps of the laterals in the two species figured are lobed, but in *T. lurida* (Dall)<sup>2</sup> and all five Western Atlantic species they are strongly dentate (Plate 138, fig. 5). The innermost laterals of the Western Atlantic species differ in shape from the three Eastern Pacific species in that they are less elongate and are not winged.

Reduction of the central tooth in this family has occurred in three ways in different groups. In *Phasianella* this tooth has become needlelike or is often absent. In *Hiloe* and related groups it has fused with the innermost pair of laterals. In *Tricolia*, s.s., it has become broad and membranous and is never cusped. In all three cases it seems to be nonfunctional.

The marginal teeth are fairly similar in all four groups. They vary little in all trochaicans. Juveniles seem to have fewer marginals than adults.

There are two main conclusions of phylogenetic significance to be drawn from this brief discussion of phasianellid radulae. One is that within the family there is great diversity in the structure of the radula. The other is that in many cases closely related species

<sup>1</sup> Pilsbry (1888, pp. 163-164) implied that there is no phylogenetic significance in the number of laterals. He ascribed the loss of the outermost pair to inefficiency of minute teeth in small species. This view is no longer tenable as most of the American species are no smaller than the Palearctic species.

<sup>2</sup> This name may not be applied correctly to this species. The holotype is apparently not the same species as the one for which this name is often used. See Woodring (1957).



Plate 138. Radulae. Fig. 1. *Phasianella australis* Gmelin. South Australia (47x). Fig. 2. *Gabrielona brevis* d'Orbigny. Antigua, Lesser Antilles (1370x). Fig. 3. *Tricolia pullus* Linné. St. Lunaire, France (280x). Fig. 4. *Tricolia compta* Gould. Santa Barbara, California (280x). Fig. 5. *Tricolia affinis affinis* C. B. Adams. Great Abaco Id., Bahama Islands (280x). Fig. 6. *Tricolia variegata* Carpenter. Bahía Magdalena, Baja California, Mexico (280x).

appear to live in the same region. For example, all the Western Atlantic species of *Tricolia* appear to be more closely related to one another than to species elsewhere. This is surprising and unusual, for as has often been pointed out, closely related species are usually allopatric.

*Phasianella* jaws consist of two plates weakly joined at the dorsal margin and placed directly above the anterior end of the radula. They probably serve to open the mouth and provide a protective surface against which the radular teeth may rub. The radula slides over the odontophore and abuts anteriorly against the jaws.

Pilsbry (1888, p. 162) describes the jaws in the whole family as "rhomboidal, covered with imbricating scales." He illustrates (pl. 60, fig. 69) the jaws of *Tricolia fordiana* (Pilsbry) from Singapore. However, the jaws of *Phasianella* differ from those of *Tricolia*. Risbec has shown (1940, p. 283) that in *P. variegata* Lamarck [= *P. rubens* Lamarck] they are not scaly. In this species the anterior edge of each plate is slightly thickened and the outer surface is minutely reticulate. The jaws of this species are figured on Plate 139, figs. 1-2. In *P. australis* (Gmelin) they are much larger, corneous and fibrous and vary considerably in thickness from specimen to specimen; some are thin and transparent while others are much thicker and amber-colored. The differences are probably due in part to age. The anterior edge of each plate is greatly thickened. The jaws of *Phasianella* are externally convex and smooth with a large posteroventral gape between them, while in *Tricolia* the plates are more or less flat and are at least occasionally scaly. Jaws may prove to be an important taxonomic character in this family, but they are fairly variable and difficult to study.

The epipodium in this family usually bears three pairs of cirri which presumably are tactile for the epipodium is innervated, as in all rhipidoglossates (Pelseneer 1888). Both the cirri and the tentacles bear fine immobile hairs. In *Tricolia* there is usually a pair of cervical lobes, also part of the epipodium. These have been described and figured for *T. pullus* (Linné) by Forbes and Hanley (1849-50), by Clark (1855) and by Jeffreys (1865). The left lobe is described by Pelseneer (1899) as being wider than the right, and Forbes and Hanley, Clark, and Jeffreys all show that there is asymmetry in other features as well, particularly in the amount of lobing. In *T. bella* (M. Smith) there is no lobe on the right side; on the left it is pedunculate and digitate and serves as a sensory structure which prevents particles in suspension in the ciliary current from entering the mantle cavity (personal observations, Bimini, Bahama Islands). According to Pelseneer (1899) the two lobes in *T. pullus* function like siphons, the one on the left being sensory, directing the ciliary current into the mantle cavity. Thus there is functional significance in the asymmetry. Cervical lobes are lacking in *Phasianella*. However, in this genus there are denticulate frontal lobes attached near the base of the tentacles. These are lacking in *Tricolia*, as has been pointed out by Pilsbry (1888, pp. 164, 167). In all probability they are not of epipodial origin, but are presumably sensory. Illustrations showing these structures in *Phasianella* are given by Quoy and Gaimard (1832-35), Kiener (1847) and Risbec (1940).

Fretter (1955) has discovered that there are two "shell" (columellar) muscles in *Tricolia pullus*, the right one being somewhat the larger. This is surprising for in all other Trochacea that have been studied there is only one. Paired columellar muscles are known in some of the Neritidae which have evolved toward a crepidula-like shell form, but it seems unlikely that this indicates any close relationship between the two families as sug-

gested by Fretter. Whether or not these paired muscles are characteristic of the entire family Phasianellidae is not known and should be investigated.

In both *Phasianella* and *Tricolia* the under side of the foot is divided by a median longitudinal furrow. The waves of progression are direct (posteroanterior) and ditaxic.

The microscopic structure of the eye of *Tricolia pullus* has been studied by Pelseneer (1891) and the nervous system of *Phasianella rubens* by Risbec (1940).

According to Fretter (1955) the gut of *T. pullus* is similar to that in trochids except that the two typhlosoles (folds) on the wall of the stomach continue along the length of the intestine and rectum to the anus which is, as a result, functionally divided into two openings. The feces are cylindrical rods, each with a longitudinal groove, and they are extruded from one of the anal openings. The other opening probably acts as a siphon allowing water to be expelled from the gut when the animal retracts into the shell.

As in all Trochacea the sexes are separate and there is no penis in the male. The sexes can be distinguished (see Fretter 1955) by the appearance of the gonad and the size of the urinogenital papilla (which is larger in the female). According to Lebour (1937) the eggs of *Tricolia pullus* are shed singly into the sea and the veliger stage is short.

The shells in this family are usually bulimoid in shape and smooth except for fine spiral sculpture. There are a few species of *Tricolia*, however, which have strong spiral cords, such as *T. bella* in the Western Atlantic and *T. bicarinata* (Dunker) of South Africa. The shell of *Gabrielona* is globose; a few species of *Tricolia* are more or less similar in shape. *Phasianella* is much larger and usually higher spired than *Tricolia*. The outer lip of *Tricolia* is prosocline, that is, it grows farther forward at the suture than at the base, and so is inclined relative to the axis. This is less marked in *Gabrielona* and *Phasianella*. Periostracum is entirely lacking in the whole family.

The paucispiral, calcareous operculum is externally convex and more or less smooth in *Phasianella* and *Tricolia* (Plate 139, figs. 6–8). In *Gabrielona*, on the other hand, it is spirally ridged externally (Plate 139, figs. 3–4). Cossmann (1918) has pointed out that in *Phasianella* there is a small parietal lamella within the aperture against which the operculum pivots. This is not present in *Gabrielona* or *Tricolia*.

The fact that both primitive and juvenile turbinids often have a perforate operculum has recently been discussed (Robertson 1957). Significantly, the juvenile operculum of *Tricolia bella* is found to be perforate (Plate 139, fig. 5). This is further indication of the fact that the Phasianellidae and Turbinidae are closely related.

There is but a single criterion by which the Phasianellidae are distinguished from the Turbinidae: lack of nacre. According to Böggild (1930) the microscopic structure of the entire shell of *Phasianella* differs considerably from that of turbinids. The form of the shell and the radula is often but not invariably diagnostic. There is also but a single criterion by which these two families are distinguished from the Trochidae: the calcareous operculum. The three families are nevertheless probably more or less natural groups.

In view of the fact that there are numerous differences between *Phasianella* and the other groups which are now placed in the Phasianellidae, two subfamilies are here recognized: the Phasianellinae, comprising the genus *Phasianella*, and the Tricoliinae, comprising the genera *Gabrielona* and *Tricolia*. The distinguishing characters are given below. Very probably these two subfamilies were derived separately from the turbinid stock and the similarities are due in part to convergence. The two groups are given subfamily rather than family rank because the family Phasianellidae itself is at best hardly distinguishable

from the Turbinidae. Thus the Phasianellidae may be considered diphyletic in origin.

The classifications of this family by Cossmann (1918) and Wenz (1938) overemphasize differences which do not prove consistent. The phylogenetic series of species leading to Recent forms suggested by Cossmann are greatly oversimplified. In some cases the relationships he suggests are clearly erroneous, especially in the case of some of the West Indian species.

The Eastern Pacific genus *Prisogaster* Mörch was thought by Thiele (1924, 1929) to be intermediate in character between the Turbininae (=Turbinidae) and Phasianellinae

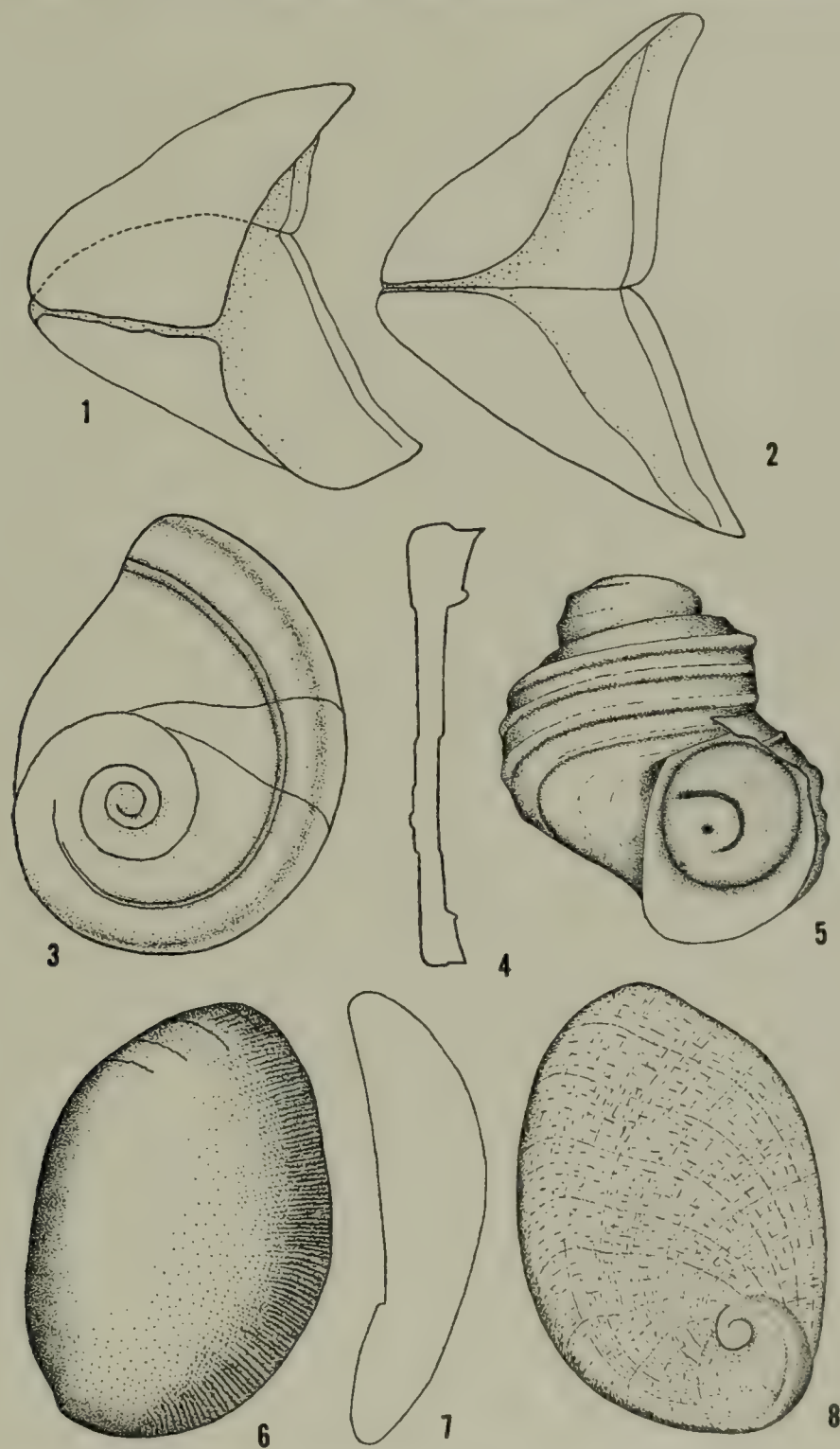


Plate 139. Figs. 1-2. Jaws of *Phasianella rubens* Lamarek. Caloundra, Queensland, Australia. Fig. 1. Oblique posteroventral view. Fig. 2. Posteroventral view (both 38x). Figs. 3-4. Operculum of *Gabrielona brevis* d'Orbigny. Antigua, Lesser Antilles. Fig. 3. External view. Fig. 4. Diagrammatic cross section (both 42x). Fig. 5. Juvenile specimen of *Tricolia bella* M. Smith showing perforate operculum. Pigeon Cays, Andros Id., Bahama Islands (50x). Figs. 6-8. Operculum of *Tricolia affinis affinis* C. B. Adams. Great Abaco Id., Bahama Islands. Fig. 6. External view. Fig. 7. Diagrammatic cross section. Fig. 8. Internal view (all 23x).

(= Phasianellidae) and he grouped it with the latter. The cusp of the wide central tooth of the radula in this genus is reduced and this suggested to Thiele affinity with *Tricolia*, s.s., in which there is no cusp at all. As the shell is nacreous within and turbinate in form, and the radula is not closely similar to that of any phasianellid, the genus is here referred back to the Turbinidae.

The genus *Pseudophasianus* Cossmann (1918), known only from Upper Eocene deposits in Europe, in all probability does not belong in the family. *Aizyella* Cossmann (1889), based on a species from Eocene deposits near Paris, is often accorded generic rank because of the spiral sculpture, but it is here ranked as a subgenus of *Tricolia* for, as mentioned above, there are Recent species which also have such spiral cords.

Some of the many supraspecific taxa in this family based on Recent species may be given subgeneric rank under *Tricolia*. The genus *Tricolia*, as here recognized, comprises the third and fourth groups mentioned above in the discussion of radulae. Despite divergence in structure of the radula there are few shell characters by which species in the two radular groups may be separated. Species in the third group may be placed in *Hilola*, *Eotricolia* and possibly *Pellax* although differences between them are relatively slight. The shells in this group are fairly thin, the suture is rather deeply impressed, the body whorl is inflated, and the edge of the outer lip is sometimes everted. In the fourth group, *Tricolia*, s.s., the shell is fairly thick and the body whorl is less inflated.

Most phasianellid species are remarkably variable, both in shell form and in coloration. One of the most important taxonomic characters is the color pattern. This is usually fairly constant within a species. The shape of the shell is also moderately constant. Much of the variability, particularly of color, is undoubtedly connected with the variety of substrates selected (and hence food), as in *Turbo* (Ino 1955).

Despite the fact that Quoy and Gaimard report (1834) that *Phasianella* is attracted to meat and that Clark (1855) invariably found foraminiferan tests in the stomach of *Tricolia pullus*, this family, like most archaeogastropods, is predominantly herbivorous. On the British coast *T. pullus* lives in the lower intertidal and Laminarian zones, particularly on the algae *Chondrus*, *Ceramium*, *Rhodophyllis* and *Rhodymenia*, and feeds on diatoms and detritus as well as the surface tissues of these red algae (Jeffreys 1865; Fretter 1955).

The West Indian species of *Tricolia* live on both marine algae and grasses; a few live among rocks, corals and even on sand, but these probably also graze on algae which are present as incrusting films. *T. thalassicola* Robertson has been dredged alive off Florida in 35 fathoms; Forbes (1844) reports that *T. pullus* lives as deep as 80 fathoms in the Aegean Sea. Most species in this family are, however, confined to shallower water where plant life is more abundant. Empty shells have been dredged in great depths in the Caribbean, but these are of no significance as such small shells can easily be transported in a variety of ways.

As far as is now known, *Tricolia affinis pterocladica* Robertson lives only on the red alga *Pterocladia*, and *T. thalassicola* predominantly on Turtle Grass (*Thalassia testudinum* Konig). This is discussed further below. Attention is here drawn to a study by Ostenfeld (1927) in which the distribution of *Thalassia* is mapped. This marine flowering plant may determine the distribution of those herbivorous snails which live on it.

*Tricolia* and *Gabrielona* are frequently drilled by predaceous gastropods (Plate 142, figs. 1, 3). More often still the outer lip is broken back by fish, but usually such damage is repaired by the animal. Brazilian specimens have been collected in the digestive tracts

of sea hares (*Aplysia*) and of starfish (Haas 1953). Empty *Tricolia* shells, many of them drilled, are remarkably abundant in sands throughout the West Indies and southern Florida. Bleached and worn protoconchs are particularly in evidence. Surprisingly enough, however, the genus is absent throughout most of the Gulf of Mexico, occurring only sporadically on the Texan and Mexican coasts and off western Florida. It may also be absent from Bermuda (see *Notes*).

Some of the syntypes (cotypes) of the five species of *Tricolia* described from Jamaica by C. B. Adams are mixtures of several species. This has been responsible for much confusion as his specimens were widely disseminated. He described the species poorly and some of the descriptions are composite.

Reeve (1862) and Sowerby (1884) incorrectly synonymized most of the West Indian species which had been named at the time with *Tricolia pullus* of Europe. Records of this species from the West Indies are thus erroneous, having been based on other species.

Pilsbry (1888) reviewed the family and laid the foundation for future work. Few taxonomic studies have been published on the Western Atlantic species since his excellent monograph.

Strong (1928) studied the Eastern Pacific species of *Tricolia*. He recognizes 11 species, 3 of which he did not see. The genus *Gabrielona* appears not to be represented. As discussed above, the radulae of the Eastern Pacific species of *Tricolia* so far studied differ consistently from those of the Western Atlantic. There are no clear-cut analogues in the two oceans. The shells of *T. cyclostoma* (Carpenter) and *T. thalassicola* do, however, resemble one another, and several of the Eastern Pacific species have oblique spiral lines of color similar to those in some of the Western Atlantic forms.

The oldest fossil American phasianellid from the Atlantic seaboard was recently named *Tricolia calypta* by Woodring (1957). It is from early Oligocene (or possibly late Eocene) deposits of the Bohio (?) Formation, Gatun Lake area, Panama Canal Zone. An early Miocene species was named *Lacuna precursor* by Dall (1915). It is from the Tampa Limestone, Florida, and, as recognized by Mansfield (1937), it also is a *Tricolia*. Other Miocene species so far described are: *Lacuna punctata* Gabb (1873) from the Cercado Formation, Dominican Republic<sup>1</sup>; *Phasianella* "doubtful species" from Trinidad (Guppy and Dall 1896); *Phasianella mollis* Olsson (1922) from the Gatun Formation, Costa Rica<sup>2</sup>; *Tricolia (Eulithidium) hadra* Woodring (1928) from the Bowden Formation, Jamaica (a *Gabrielona*?); *Tricolia probrevis* Gardner (the holotype is juvenile), *Didianema ? waltonia* Gardner (a *Gabrielona*?) and *Tricolia affinis chipolana* Gardner (1947), all from the Alum Bluff Group, Florida, and *Tricolia ? syntoma* Woodring (1957) of the Gatun Formation, Panama (a *Gabrielona*?). With the exception of the three species which may be referred to *Gabrielona* all these Miocene forms are similar to *T. affinis* (C. B. Adams), a highly variable Recent species. Pliocene fossils have all been referred to Recent species. It should be stated that the remarks made here about these

<sup>1</sup> As there was a prior *Tricolia punctata*, Woodring (1928) renamed this *T. (Tricolia) affinis gabbi*.

<sup>2</sup> This was synonymized by Woodring (1928) with *T. umbilicata* (d'Orbigny), a homonym, as shown in the synonymies below, which has been applied to two Recent species: *T. affinis* and *T. thalassicola*. *T. mollis* may be a synonym of *T. affinis*, but the status of the name will remain in doubt until the type is examined. This type should be in the Paleontological Research Institution, Ithaca, New York, but cannot at present be located. Aguayo (1945) has suggested using Olsson's name in place of *T. umbilicata*.

fossils are made solely on the basis of descriptions and illustrations in the literature, not on specimens. Hence they are especially open to question.

Finlay (1926) and Cotton and Godfrey (1938) use the name Eutropiidae (Eutropiinae H. and A. Adams 1854) for the Phasianellidae. This is inadmissible because the name is based on an objective junior synonym of *Phasianella*. The name Phasianellidae is already well established. Cotton himself does not use the name *Eutropia*.

#### ACKNOWLEDGMENTS

Without the help and cooperation of many individuals this work could not have been completed. Approximately 20,000 Western Atlantic specimens were examined during the study. Well over half of these were sent on loan. To Dr. William J. Clench and to Dr. Ruth D. Turner, under whose direction the work was carried out, I am greatly indebted. All the facilities of the Mollusk Department in the Museum of Comparative Zoölogy (MCZ) were kindly placed at my disposal. To Dr. Myra Keen, Stanford University (LSJU), under whom the work was started, I am also deeply grateful, and to those who so kindly sent material on loan and in many cases gave important information as well. I would particularly like to mention Dr. R. Tucker Abbott, Academy of Natural Sciences of Philadelphia (ANSP); Dr. Fritz Haas, Chicago Natural History Museum (CNHM); Dr. Leo G. Hertlein, California Academy of Sciences (CAS); Mr. Thomas L. McGinty, Boynton Beach, Florida; Dr. Donald F. McMichael, Australian Museum, Sydney; Dr. Harald A. Rehder, United States National Museum (USNM), and Mrs. Germaine L. Warmke, Mayagüez, Puerto Rico. The following also very kindly sent material on loan: Mr. R. M. DeWitt, Florida State Museum (FSM); Mr. George F. Kline, Madison, New Jersey; Mr. Donald R. Moore, Ocean Springs, Mississippi; Dr. and Mrs. David Schmidt, Sarona, Wisconsin; Dr. Henry van der Schalie, Museum of Zoology, University of Michigan (U of M); Dr. Gilbert L. Voss, University of Miami Marine Laboratory (ML), and Mr. Frederick V. Weir, American Museum of Natural History (AMNH).

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#### Family PHASIANELLIDAE

##### Subfamily PHASIANELLINAE

Adult shell 1 to 10 cm. in length, oval, smooth and polished. Spire high, produced at an angle of from  $45^{\circ}$  to  $55^{\circ}$ . Whorls evenly rounded. There is a callus on the parietal region but no umbilicus. The color pattern is made up in part of spiral lines or bands. The operculum, which is externally convex and more or less smooth, pivots against a weak axial lamella on the columella, well within the aperture. The aperture is oval and the outer lip fairly thin and weakly prosocline.

The central tooth of the radula, when present, is needlelike. Each of the five paired laterals has an entire cusp and an elongate longitudinal attachment to the ribbon; the transverse rows are fairly straight. The plates of the jaw are externally convex.

Frontal lobes are present on the head, but there are no cervical lobes.

### Genus *Phasianella* Lamarck

*Phasianella* Lamarck 1804, Annales du Muséum National d'Histoire Naturelle (Paris) **4**, p. 295.

*Phasianus* Montfort 1810, Conchyliologie Systématique **2**, p. 255 [emendation of *Phasianella* Lamarck]; non *Phasianus* Linné 1758 [Aves].

*Bolina* Rafinesque 1815, Analyse de la Nature, Palermo, p. 144 [new name for *Phasianella* Lamarck].

*Eutropia* 'Humphrey' Swainson 1840, Treatise on Malacology, p. 21 [merely listed as a synonym of *Phasianella* Lamarck]; 'Humphrey' H. and A. Adams 1854, Genera of Recent Mollusca, London, **1**, pp. 389-390.

*Orthopnoea* Gistel and Bromme [1847] 1850, Handbuch der Naturgeschichte, p. 556; Gistel 1848, Naturgeschichte des Thierreichs für höhere Schulen, pp. 169, 199 [new name for *Phasianella* Lamarck].

*Orthomesus* Pilsbry 1888, Manual of Conchology (1) **10**, pp. 163, 179 (type species, *Phasianella variegata* Lamarck 1822, non *P. variegata* de Roissy 1805 [= *P. rubens* Lamarck 1822], by original designation).

*Mimelenchus* Iredale 1924, Proceedings of the Linnean Society of New South Wales **49**, pp. 182, 232 (type species, *Phasianella ventricosa* Swainson<sup>1</sup> 1822, by monotypy).

Type species: "faisan" [= *Buccinum australe* Gmelin 1791], by subsequent selection, de Roissy 1805.

The characters given above for the subfamily apply to the genus.

Lamarck based his description of the genus on the "faisan" but in the same paper described two fossil species (now referred to *Tricolia*) from the Paris Basin. Harris (1897) has selected *Phasianella turbinoides* Lamarck 1804 as type. Woodring (1928) argued that the type species is the "faisan" by original designation. Lamarck, however, did not use the word 'type' when referring to this species. Fortunately de Roissy selected it as type in 1805, as has been discussed recently by Woodring (1957). The selection made by Harris is therefore invalid.

Neither the shell nor the radula of *Orthomesus* or *Mimelenchus* differs in any significant way from *Phasianella*, s.s.

A figure of a radula published by Eberhard (1865) which was believed by Troschel (1878) to be that of *Phasianella australis* has caused much confusion, for it was a *Tricolia* (probably *T. pullus*), not a *Phasianella*. Pilsbry named *Orthomesus* as a result of this misapprehension. For a long time the major differences between the radulae of *Phasianella* and *Tricolia* were thus not realized. Iredale (1924) and Thiele (1924) were the first to point this out.

The oldest undoubted representatives of this genus appear to be from rocks of Miocene age in Java and Victoria, Australia (Martin 1916; Cressin 1926).

The following synonymy is of the type species of the genus.

### *Phasianella australis* Gmelin

Plate 136; Plate 138, fig. 1

*Buccinum australe* Gmelin 1791, Systema Naturae, ed. 13, p. 3490 (rivers of New Zealand) [based on Favanne de Montcervelle 1784, Catalogue Systématique et Raisonné ou Description du Magnifique Cabinet Ap-

<sup>1</sup> See Iredale's discussion (1924) of Swainson's use of this name prior to Quoy and Gaimard (1834) for the same species.

partenant ci-devant à M. le C[omte] de [La Tour d'Auvergne], p. 11, pl. 1, fig. 46, and Chemnitz 1786, Conchylien-Cabinet (1) **9**, pt. 2, pp. 38-40, pl. 120, figs. 1033-1034].

*Helix phasianus* Röding 1798, Museum Boltenianum, p. 108 [based on Chemnitz 1786, pl. 120, figs. 1033-1034].

*Phasianella variegata*<sup>1</sup> de Roissy 1805, Histoire Naturelle Générale et Particulière des Mollusques **5**, p. 331 (islands near New Holland [Australia]) [based on Chemnitz 1786, pl. 120, figs. 1033-1034].

*Phasianus variegatus* de Roissy. Montfort 1810, Conchyliologie Systématique **2**, p. 255.

*Bulimus phasianus* Perry 1810, Arcana, sign. Y, 7th page, pl. 43 (New Holland and Van Diemen's Land [Australia and Tasmania]); Perry 1811, Conchology, or the Natural History of Shells, pl. 30, fig. 4.

*Trochus phasianella* ? Brookes 1815, An Introduction to the study of Conchology, p. 163, pl. 7, fig. 96.

*Phasianella varia* Lamarck 1816, Tableau Encyclopédique et Méthodique, Mollusques et Polypes Divers, Liste, p. 10, pl. 449, figs. 1a, b, c.

*Phasianella bulimoides* Lamarck 1822, Histoire Naturelle des Animaux sans Vertèbres **7**, p. 52 (seas of New Zealand and New Holland [Australia], common near Maria Id. [off eastern Tasmania]) [based on *Buccinum australe* Gmelin and the preceding].

*Phasianella picta* de Blainville 1825, Manuel de Malacologie, p. 439; 1827, pl. 37, figs. 5, 5a.

*Phasianella tritonis* 'Chemnitz' Anton 1839, Verzeichniss Conchylien, Halle, p. 60.

*Phasianella lehmanni* Menke 1843, Molluscorum Novae Hollandiae, p. 12.

*Phasianella preissii* Menke 1843, Molluscorum Novae Hollandiae, p. 12.

*Phasianella venusta* Reeve 1848, Elements of Conchology **1**, p. 132, pl. 12, fig. 58.

*Phasianella decorata* Chenu 1859, Manuel de Conchyliologie **1**, pp. 342-343, fig. 2530.

*Phasianella pulchella* Tenison-Woods 1877, Papers and Proceedings and Report of the Royal Society of Tasmania for 1876, p. 141 (Long Bay, Tasmania) [juvenile]; non *P. pulchella* Récluz 1843.

*Phasianella delicatula* Tenison-Woods 1878, Papers and Proceedings and Report of the Royal Society of Tasmania for 1877, p. 38 [new name for *P. pulchella* Tenison-Woods 1877, non *P. pulchella* Récluz 1843].

*Phasianella australis* Gmelin var. *subsanguinea* Pilsbry 1888, Manual of Conchology (1) **10**, p. 165, pl. 38, fig. 52.

This species ranges from Western Australia east along the south coast to Victoria and Tasmania. The type locality (rivers of New Zealand) is erroneous. For further information see Cotton (1945).

### Subfamily TRICOLIINAE

Adult shell normally less than 1 cm. in length. Spire usually produced at an angle of 60° or more. Shape and sculpture various, but spiral grooves are often present, particularly on the early whorls. Small species are perforate; large species are imperforate when adult. Color pattern various. Aperture oval or semicircular. A parietal lamella is absent. In *Tricolia* the operculum is similar to that of *Phasianella*; in *Gabrielona* it is naticoid.

The central tooth of the radula may have an entire cusp, may be reduced to a membranous plate, or may be lacking altogether. In the latter case the innermost laterals have fused to form a pseudocentral tooth and the free laterals are reduced in number to two or three pairs.

There are cervical lobes but no frontal lobes on the head.

<sup>1</sup> This name invalidates *Phasianella variegata* Lamarck 1822 (Histoire Naturelle des Animaux sans Vertèbres **7**, p. 53). The species to which this name has been applied may take the name *Phasianella rubens*, introduced by Lamarck on the same page for a different (possibly geographic) form of the same species. Iredale (1924) and Cotton (1945) believe these are distinct species: this is here believed incorrect. If, however, it can be shown that they are specifically distinct, the name *Turbo lineolatus* Wood (1828, Index Testaceologicus, Supplement, p. 19, pl. 6, **Turbo**, fig. 26 [*Phasianella lineolatus*, p. 48]) is available instead of *P. rubens* for *P. variegata* Lamarck.

Woodring (1928) applied the name *Tricoliidae* to this group, separating it from the *Phasianellidae*.

### Genus *Gabrielona* Iredale

*Gabrielona* Iredale 1917, Proceedings Malacological Society of London **12**, p. 327.

*Gabrielana* 'Iredale' Cossmann 1918, Revue Critique de Paléozoologie **22**, p. 42 [error for *Gabrielona*].

Type species: *Phasianella nepeanensis* Gatliff and Gabriel 1908, by monotypy.

Adult shell not more than 2.4 mm. in length, globose, wider than long. Spire low, usually produced at an angle of about  $110^{\circ}$ . Shell smooth or with fine incised spiral grooves. An umbilicus is present. Whorls inflated. Shell pink or red-brown and white. Aperture semicircular with the outer lip weakly prosocline. The operculum spirally ridged externally, thinnest near the center and thickest near the margin. The central tooth of the radula is large and has an entire cusp. Five pairs of laterals are present, the cusps of which are also entire.

In their original description of the type species of *Gabrielona*, Gatliff and Gabriel (1908) mention a similarity to the type species of *Chromotis* H. and A. Adams. This no doubt induced Thiele (1929) to synonymize *Gabrielona* tentatively with *Chromotis*. However, *Chromotis* is a subjective synonym of *Tricolia* based on a species with an externally convex operculum. As stated by Iredale, the operculum of *Gabrielona* is naticoid and, in addition, there are marked differences in the shell by which this genus differs from *Tricolia*.

*Phasianella brevis* d'Orbigny is here referred to this genus because of the similarity of the operculum, color pattern and shell form to that of the type species. Dall (1889a) wrongly referred it to *Eucosmia* Carpenter [= *Eulithidium*]. As discussed in the introduction, the radula of this species is of a distinct form.

*Tricolia* (*Eulithidium*) *hadra* Woodring (1928), *Didianema* ? *waltonia* Gardner (1947) and *Tricolia* ? *syntoma* Woodring (1957) may provisionally be referred also to this genus, pending knowledge of the opercula of these Miocene forms.



Plate 140. Fig. 1. *Gabrielona nepeanensis* Gatliff and Gabriel. Ocean Beach, near Point Nepean, Victoria, Australia (27x). Paratype, Australian Museum, no. C. 45057. Juvenile specimen with a slightly broken outer lip. Figs. 2-3. *Gabrielona brevis* d'Orbigny. Fig. 2. Antigua, Lesser Antilles (23x). Fig. 3. Off Bahía Honda, Pinar del Río, Cuba (25.5x). Same specimen figured by Dall 1889, pl. 19, fig. 10b.

**Gabrielona nepeanensis** Gatliff and Gabriel

Plate 137, figs. 2-3; Plate 140, fig. 1

*Phasianella nepeanensis* Gatliff and Gabriel 1908, Proceedings Royal Society of Victoria (n.s.) **21**, p. 366, pl. 21, figs. 9-10 [reproduced here] (Flinders, Western Port; Ocean Beach, near Point Nepean [Victoria, Australia]); Iredale 1917, Proceedings Malacological Society of London **12**, p. 327.

*Gabrielona nepeanensis* Gatliff and Gabriel. Cotton 1945, Transactions Royal Society of South Australia **69**, p. 165.

This, the type species of *Gabrielona*, is known only from the type locality in Victoria and possibly from two localities in South Australia. It is likely that Cotton (1945) has misidentified this species, for he states that his specimens are separated with difficulty from "*Pellax virgo*." The two species are easily distinguished, for they differ greatly in shape and in the structure of the operculum.

**Gabrielona brevis** d'Orbigny

Plate 138, fig. 2; Plate 139, figs. 3-4; Plate 140, figs. 2-3; Plate 141; Plate 142, fig. 1

*Phasianella brevis* d'Orbigny 1842 [in] Ramon de la Sagra, Histoire de l'Ile de Cuba, Mollusques **2**, p. 79, pl. 20, figs. 19-21 (Martinique and Cuba).

*Phasianella brevissima* Pilsbry 1888, Manual of Conchology (1) **10**, p. 179 [new name for *P. brevis* d'Orbigny 1842, non *P. brevis* C. B. Adams 1850].

*Phasianella* (*Eucosmia*) *brevis* d'Orbigny. Dall 1889, Bulletin Museum of Comparative Zoölogy **18**, p. 351, pl. 19, fig. 10b [*Eucosmia brevis* on plate explanation].

*Eucosmia brevis* d'Orbigny. Cossmann 1918, Essais de Paléoconchologie Comparée, Paris, livr. **11**, p. 162, fig. 55.

*Tricolia brevis* d'Orbigny. Aguayo 1943, Revista de la Sociedad Malacológica **1**, pp. 39-40.

**Description.** Shell moderately thin, globose, inflated and reaching 2.4 mm. in length. The color pattern is made up of light to dark brick-red irregular wavy stripes on white. The columellar area is either white and demarcated from the surrounding light brick-red by a crenulate margin, or there are more or less square white spots in a spiral series on dark brick-red. The wavy stripes are widest below the suture and below the periphery. There may be merely series of flames above and below the periphery on the initial whorls. In one specimen the dark wavy stripes are so wide that they have fused to leave wavy white lines on a dark brick-red ground color. Whorls 4, greatly inflated. Spire depressed, set at an angle of 110°. Protoconch minute, depressed and white. Aperture pyriform-ovate. Columellar callus fairly thick, margin raised slightly near the umbilicus. Umbilicus narrow. Suture slightly impressed. Post-nuclear whorls usually with evenly spaced spiral striae; the striae gradually become weaker so that the body whorl is entirely smooth. One specimen is entirely smooth and polished. Operculum (Plate 139, figs. 3-4) naticoid, more or less flat, but ridged near the margin and thinnest at the center.

	length	width	
	2.4 mm.	2.2 mm.	Antigua, Lesser Antilles
	2.0	2.4	Off Bahía Honda, Cuba
	1.5	1.6	Antigua, Lesser Antilles
(juvenile)	1.5	1.4	Habana, Cuba

**Types.** Three syntypes of *Phasianella brevis* d'Orbigny (one is illustrated here, Plate 142, fig. 1) are in the British Museum (Natural History), no. 54.10.4.282. Gray (1854)

states that all the d'Orbigny types from Cuba were sent to the Museum.<sup>1</sup> They are from Martinique, however, not Cuba as implied by the title of Gray's list. The Cuban specimen(s) mentioned by d'Orbigny may thus have been lost, or were not regarded as types and retained by d'Orbigny. The type locality is Martinique, Lesser Antilles.

*Remarks.* This species can easily be distinguished from other Western Atlantic phasianellids because the shell is as wide as it is long, or almost so, and the operculum is naticoid. The light to dark brick-red color is also characteristic; there are no spots.

Only thirteen specimens were available for this study. Eleven of them were collected at Antigua by J. B. Henderson, Jr.; one was dredged dead in deep water off Bahía Honda, Cuba, by the *Blake*, and one juvenile is from near Habana, Cuba. The Cuban specimen from deep water differs from the Antiguan specimens in that it is smooth and predominantly dark brick-red, with wavy white streaks, and the outer lip is thickened. All the Antiguan specimens have spiral striae, particularly on the early whorls. They are white, with wavy pale brick-red stripes. The outer lip is thin, even though some of the specimens are larger than the one from Cuba.

One of the Antiguan specimens was collected alive in "deep, fine sand and shells," apparently in shallow water.

Dall (1889a) identified the Cuban specimen from deep water with d'Orbigny's species; however, he misidentified the deep water form of *Tricolia thalassicola* with this species also, as well as juvenile specimens of other West Indian species. The published ranges of this species have been incorrect as a result.

*Tricolia probrevis* Gardner (1947) was implied to be a precursor of this species. However, it is a juvenile *Tricolia*, not a *Gabrielona*. The specimens with which it was compared were probably misidentified.

Six worn and broken specimens in the United States National Museum (no. 150781) from Ilha de São Sebastião, São Paulo, Brasil, collected by H. von Ihering, may possibly represent another Western Atlantic species of *Gabrielona*. What little remains of the color pattern consists of irregular red-brown spots. The spire is higher than in *G. brevis*, being produced at an angle of about 85°, and the umbilicus is more prominent. The largest specimen is 1.9 mm. in length. Several of the specimens show traces of spiral striae. The Brazilian record of "*Eulithidium brevissimum* (Pilsbry)" given by Lange de Morretes (1949) may have been based on specimens from the same lot.



Plate 141. *Gabrielona brevis* d'Orbigny. Fig. 1. Antigua, Lesser Antilles. Fig. 2. Off Bahia Honda, Pinar del Río, Cuba. Same specimen figured by Dall 1889, pl. 19, fig. 10b (both 13x).

<sup>1</sup> In the notes made by P. P. Carpenter while at the Museum in 1863-64 which have been published by Palmer (1947) it is stated that these specimens are "a *Glabella*, very like the commoner *C. S. Lucas* sp." [Cape San Lucas, Baja California, Mexico]. *Glabella* Swainson is a marginellid; possibly Carpenter intended to use this name for the group he shortly afterwards called *Eucosmia* in a paper describing new species from Cape San Lucas.

*Range.* Cuba, Antigua and Martinique (d'Orbigny).

*Specimens examined.* CUBA: *Blake*, station 21 [1877-78] (N. Lat. 23°2'; W. Long. 83°13') in 287 fathoms (dead), off Bahía Honda, Pinar del Río (USNM); Arenas de la Chorrera, Habana (MCZ). LESSER ANTILLES: English Harbour, Antigua (USNM).

### Genus *Tricolia* Risso

*Tricolia* Risso 1826, *Histoire Naturelle de l'Europe Méridionale*, Paris, 4, p. 122.

*Tricolea* "Risso," *Thicolea* "Leach MSS. 1819," *Tricolaea*, all Gray 1847, *Proceedings of the Zoological Society of London* 15, pp. 144, 218 [errors for *Tricolia* Risso].

*Eudora* 'Leach' Gray 1852, *Synopsis of the Mollusca of Great Britain*, pp. 147, 199 (type species, *Eudora varians* 'Leach' Gray 1852 [= *Turbo pullus* Linné 1758], by monotypy); non *Eudora* Péron and Lesueur 1810 [Coelenterata], etc.

*Chromotis* H. and A. Adams 1863, *Annals and Magazine of Natural History* (3) 11, pp. 19-20 (type species, *Chromotis neritina* Dunker [= *Phasianella neritina* Dunker 1846], by monotypy).

*Eucosmia* Carpenter 1864, *Annals and Magazine of Natural History* (3) 13, p. 475 (type species, *Eucosmia variegata* Carpenter 1864, by subsequent selection, Pilsbry 1888); non *Eucosmia* Stephens 1831 [Lepidoptera].

*Tricoliella* Monterosato 1884, *Il Naturalista Siciliano* 3, p. 110 (type species, *Tricolia pullus* Linné 1758, by subsequent selection, Pilsbry 1888).

*Steganomphalus* Harris and Burrows 1891, *Eocene & Oligocene Beds of the Paris Basin*, London, pp. 78-79, 112 [new name for *Eudora* 'Leach' Gray 1852, non *Eudora* Péron and Lesueur 1810, etc.].

*Eulithidium* Pilsbry 1898, *Nautilus* 12, p. 60 [new name for *Eucosmia* Carpenter 1864, non *Eucosmia* Stephens 1831].

*Tricola* Strong 1928, *Proceedings California Academy of Sciences* (4) 17, pp. 189, 191-193, 202 [error for *Tricolia* Risso].

*Usatricolia* Habe 1956, *Venus* 19, pp. 95-96, 98 (type species, *Phasianella compta* Gould 1855, by monotypy).

Type species: *Turbo pullus* Linné 1758 [= *Tricolia pullus* Linné], by subsequent selection, Gray 1847 [misspelled "*Tricolea*"].

Adult shell rarely over 1 cm. in length, globose, oval or elongate, usually smooth, but a few species have strong spiral cords. Spire moderately elevated, usually produced at an angle of from 60° to 80°, but very occasionally as low as 100° or as high as 40°. Initial whorls sometimes with strong spiral threads. Shell imperforate or rimately perforate. Color pattern various, often consisting in part of oblique spiral lines. Aperture oval. Outer lip strongly prosocline. Operculum white, externally convex and more or less smooth, perforate when juvenile. Cervical lobes are present, but not frontal lobes. The plates of the jaw are more or less flat.

The type species of *Chromotis*, from South Africa, is low-spired. However, the radula differs in no observable way from that of *Tricolia pullus* and the operculum has the same general form as in all other species of *Tricolia*. As there are several species transitional in shell form, it seems unnecessary to maintain such monotypic subgenera.

Low-spired forms of *Tricolia* (especially American species) have frequently been referred to *Eulithidium*. However, the spire of the type species (Plate 148, fig. 1) is no lower than in *Tricolia*, s.s. (Plate 137, fig. 1). The assemblage of species referred by Dall (1908) to this subgenus is clearly heterogeneous. As discussed in the introduction, the radulae of the American species of *Tricolia* differ consistently from those from the Old World in having four rather than five pairs of radular laterals. The name *Eulithidium* could be applied subgenerically to the American species, but at the present time it is

thought that this would be confusing for this name has long been applied incorrectly only to low-spired species.

*Usatricolia* was separated from *Tricolia* because the central tooth of the radula was "distinctly transversely narrower" and because there were four pairs of laterals rather than five. There is great variability in the shape of the central tooth, even in a single radula. The tooth figured by Habe is merely abraded. The radula of *Usatricolia* (Plate 138, fig. 4) is strikingly similar to that of *Eulithidium* (Plate 138, fig. 6) and the two cannot possibly be considered even subgenerically distinct (Plate 148). Both have four pairs of laterals.

Six subgenera may be recognized within the genus: *Tricolia*, s.s., *Aizyella* Cossmann (1889), *Phasianochilus* Cossmann (1918), *Hilola* Pilsbry (1917), *Pellax* Finlay (1926) and *Eotricolia* Kuroda and Habe (1954).

### Subgenus *Tricolia*

Shell fairly thick; suture never deeply impressed; whorls moderately inflated. Central tooth of the radula not cusped, reduced to a membranous plate. Four or five pairs of laterals are present, each with incised cusps. Rows of lateromarginal plates lie between the marginals and laterals.

All the Western Atlantic species belong in this subgenus.

Varietal names are omitted in the following synonymy of the type species. For more complete synonymies, which include some of the many varietal names, see Bucquoy, Dautzenberg and Dollfus (1884) and Priolo (1953).

### *Tricolia pullus* Linné

Plate 137, fig. 1; Plate 138, fig. 3

*Turbo pullus*<sup>1</sup> Linné 1758, *Systema Naturae*, ed. 10, p. 761 (Mediterranean Sea); Hanley 1855, *Ipsa Linnaei Conchylii*, pp. 327-328.

*Turbo pictus* da Costa 1778, *British Conchology*, p. 103, pl. 8, figs. 1, 3 (coast of Cornwall, and Exmouth, Devonshire; Mediterranean) [refers to the preceding].

*Turbo flammeus* von Salis 1793, *Reisen in versch. Prov. Königreich Neapel*, p. 377, pl. 8, fig. 11 (Naples, Italy). Not seen.

*Phasianella pullus* Linné. Sowerby 1825, *Catalogue of the Shells contained in the collection of the late Earl of Tankerville*, p. 56.

*Tricolia pullus* Linné. Risso 1826, *Histoire Naturelle de l'Europe Méridionale*, Paris, 4, p. 123.

*Tricolia punctata* Risso 1826, *Histoire Naturelle de l'Europe Méridionale* 4, p. 123 (coast of Provence).

*Phasianella pullulus* Anton 1839, *Verzeichniss Conchylien*, Halle, p. 60.

*Phasianella pulchella* Récluz 1843, *Revue Zoologique par la Société Cuvierienne* 6, pp. 10-11 (coasts of the English Channel).

*Phasianella tenuis* Philippi 1844, *Zeitschrift für Malakozoologie* 1, p. 110 (Sicily); non *P. tenuis* Michaud 1829.

*Eudora varians* 'Leach' Gray 1852, *Synopsis of the Mollusca of Great Britain*, p. 200 [new name for *Turbo pullus* Linné 1758].

*Phasianella crassa* Brusina 1864, *Verhandlungen zoologisch-botanischen Gesellschaft in Wien* 15, p. 23 (Dalmatia).

? *Phasianella exigua* Brusina 1864, *Verhandlungen zoologisch-botanischen Gesellschaft in Wien* 15, p. 24 (Dalmatia).

<sup>1</sup> The name *Pullus* was capitalized by Linné, indicating that he used it as a noun. See Cooke 1899, *Journal of Malacology* 7, pp. 31-32.

? *Tricoliella jolyi* Monterosato 1889, Journal de Conchyliologie **37**, p. 30 (Casablanca and near Algiers).  
*Eudora dubia* Monterosato 1889, Journal de Conchyliologie **37**, p. 31 (Casablanca).

This species ranges from the British Isles south to West Africa, west to the Azores and east along the shores of the Mediterranean to the Black Sea.

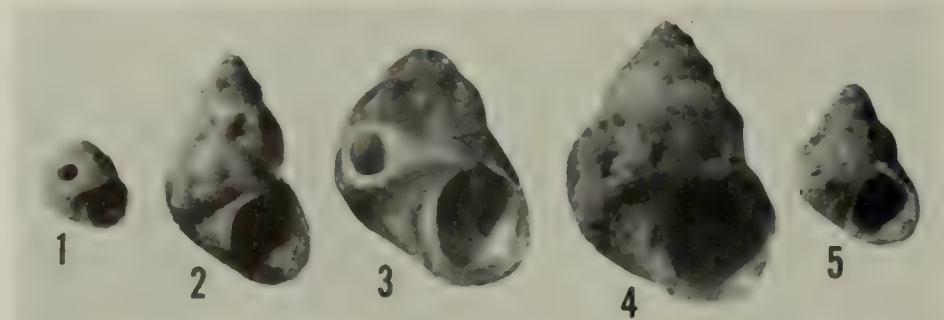


Plate 142. Figs. 1-3. D'Orbigny types. Fig. 1. *Phasianella brevis* [= *Gabrielona brevis*]. Syntype, Martinique, Lesser Antilles (6x). Fig. 2. *Phasianella umbilicata* [= *Tricolia thalassicola* Robertson]. Invalid syntype, Cuba (4x). Fig. 3. *Phasianella zebrina* [= *Tricolia tessellata* Potiez and Michaud]. Syntype, Guadeloupe, Lesser Antilles (6x). Figs. 4-5. Syntypes of *Littorina adamsii* Reeve [= *Tricolia bella* M. Smith]. Jamaica (both 6x).  
 Photographs by courtesy of the British Museum (Natural History).

### *Tricolia affinis affinis* C. B. Adams

Plate 138, fig. 5; Plate 139, figs. 6-8; Plate 143, figs. 1-2; Plate 145, fig. 1

*Phasianella umbilicata* d'Orbigny 1842 [in] Ramon de la Sagra, Histoire de l'Ile de Cuba, Mollusques **2**, p. 77, pl. 19, figs. 32-34 (Martinique, Guadeloupe, Jamaica and Cuba) [in part only]; non *Littorina umbilicata* d'Orbigny 1840 [a *Tricolia*].

*Phasianella affinis* C. B. Adams 1850, Contributions to Conchology, no. 4, p. 67 (Jamaica).

*Phasianella concinna* C. B. Adams 1850, Contributions to Conchology, no. 5, p. 69 (Jamaica).

**Description.** Shell fairly thin, inflated, elongate, reaching 8 mm. in length. The color pattern consists of irregularly arranged minute brick-red or red dots each of which is usually paired with a somewhat larger white spot. These are produced subsequent to each red dot in spiral sequence. The ground color is light orange-brown or pink and is partially transparent. Irregular wavy axial streaks are superimposed which are either red or alternately light brick-red and white. The white streaks are often broken at the periphery. Occasionally the whole shell is suffused with rose. Whorls 5, evenly rounded. Spire produced at an angle of from 60° to 63°. Protoconch minute, depressed and colored white or pale pink. Aperture elongate-ovate. Columella with a thick white callosity. Umbilicus fairly wide. Suture impressed. Post-nuclear whorls smooth except for minute spiral striae. Operculum elongate, white and minutely striated exteriorly. The striae are near and at right angles to the margin.

	length	width	
	7.5 mm.	5.0 mm.	Lectotype of <i>Phasianella affinis</i> C. B. Adams
	6.8	4.2	Norris Cut, near Miami, Florida
	5.0	3.2	Aguadilla, Puerto Rico
(juvenile)	2.7	1.9	Big Pine Key, Florida

**Types.** The lectotype of *Phasianella affinis* C. B. Adams (Plate 143, fig. 2), selected by Clench and Turner (1950, pl. 36, fig. 6), is in the Museum of Comparative Zoölogy, no. 186020. Lectoparatypes from Jamaica are in the United States National Museum

(no. 61764) and the Academy of Natural Sciences of Philadelphia (no. 199422). The lectotype of *Phasianella concinna* C. B. Adams (Plate 143, fig. 1), also selected by Clench and Turner (1950, pl. 36, fig. 4), is in the United States National Museum, no. 54766. See under *T. thalassicola* concerning *Phasianella umbilicata* d'Orbigny. The type locality of this species is Jamaica.

**Remarks.** This is the largest and one of the most abundant forms of *Tricolia* in the West Indies. See *Remarks* on other species and subspecies of *Tricolia* for characters by which it may be distinguished. In the Florida Keys it lives predominantly on Turtle Grass (*Thalassia testudinum* König); at Great Abaco, in the northern Bahama Islands, it was collected alive by the writer both in deep crevices in dead coral and on *Thalassia*.

**Range.** The Florida Keys, the Bahama Islands, the Greater Antilles east to Saint Martin, northern Lesser Antilles. Replaced in most of the remainder of the Lesser Antilles by *T. affinis beaufi*, by *T. affinis cruenta* on the continental shores of the Caribbean and the coast of Brasil, and by *T. affinis pterocladica* north of the vicinity of Miami, Florida.

**Specimens examined.** FLORIDA: Miami Beach (FSM); Fisher Id., Miami (T. McGinty); Norris Cut (MCZ); Key Largo (MCZ; ANSP; ML; CNHM; D. Moore); Teatable Key (FSM; T. McGinty); Lower Matecumbe Key (USNM); Little Duck Key (T. McGinty); West Sister Key, off Vaca Key (FSM); Bahia Honda Key (T. McGinty);

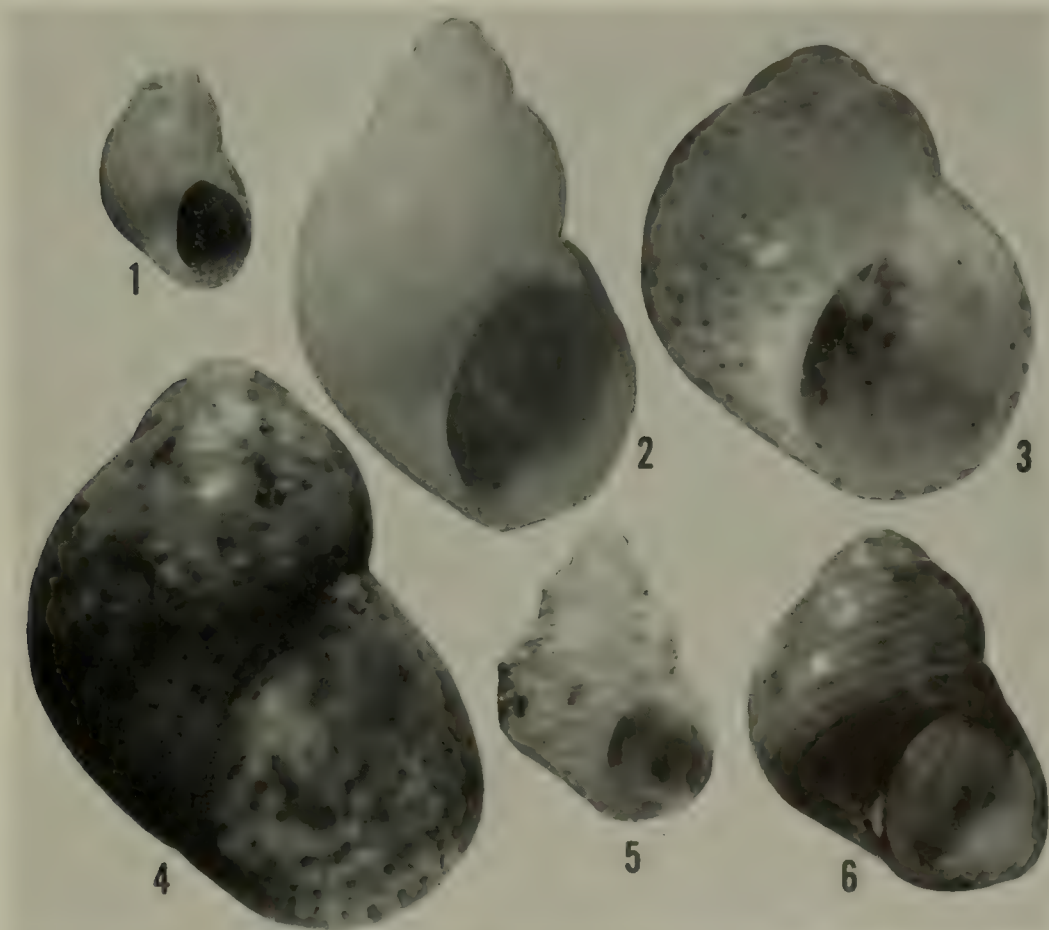


Plate 143. C. B. Adams types. Fig. 1. *Phasianella concinna* [= *Tricolia affinis affinis* C. B. Adams]. Lectotype, Jamaica (4x). Fig. 2. *Phasianella affinis* [= *Tricolia affinis affinis*]. Lectotype, Jamaica (8x). Fig. 3. *Phasianella brevis* [= *Tricolia adamsi* Philippi]. Holotype, Jamaica (16.5x). Fig. 4. *Phasianella brevis* [= *Tricolia adamsi* Philippi]. Invalid neotype, St. Thomas, Virgin Islands (15x). Fig. 5. *Turbo* (?) *pulchellus* [= *Tricolia bella* M. Smith]. Lectotype, Jamaica (10x). Fig. 6. *Phasianella tessellata* [= *Tricolia tessellata* Potiez and Michaud]. Lectotype, Jamaica (10x).

D. and N. E. Schmidt); Big Pine Key: Summerland Key (both D. and N. E. Schmidt); Middle Sambo Shoals, S of Boca Chica Key (T. McGinty); Boca Grande Key; Garden Key (both FSM); Loggerhead Key (T. McGinty), both Dry Tortugas. BAHAMA ISLANDS: Elbow Cay, Great Abaco Id. (R. Robertson); S of North Cay, in 2 fathoms; off Nassau Harbour; Lyford Cay, all New Providence (all T. McGinty); Governors Harbour, Eleuthera; Campdown, northern Cat Island (both MCZ). CUBA: Cabo San Antonio; Cabo Cajon; off Los Arroyos; Dimas, in 4–5 fathoms; Santa Lucía, in 2–4 fathoms; La Esperanza; Cayo Arenas, in 2 fathoms; Cayo Levisa, in 2–3 fathoms; Cabañas, all Pinar del Río (all USNM); near Habana, Habana; Bahía de Cárdenas, Matanzas (both ANSP); off Cayo Fragoso; Caibarién, both Las Villas; off Punta Alegre, Camagüey; Guarda la Vaca, near Puerto Samá, Oriente (all MCZ). JAMAICA: (MCZ: AMNH: CNHM); Jack's Bay, St. Mary (USNM); Port Antonio, Portland (ANSP); Port Royal (USNM). HISPANIOLA: Cap Haïtien, Dépt. du Nord (MCZ); Port Salut; Les Cayes; Aquin, all Dépt. du Sud; Saltrou, Dépt. de l'Ouest, all Haiti (all USNM); Montecristi; El Canal, Cabo Macoris (both MCZ); Bahía de Samaná (USNM), all Dominican Republic. PUERTO RICO: Aguadilla (G. Warmke); Arecibo; Boca de Congrejos (both MCZ); Guánica (AMNH); Cabo Rojo (G. Warmke: MCZ); Rincón (LSJU). VIRGIN ISLANDS: St. Thomas (MCZ: USNM; CNHM); St. John (MCZ). LESSER ANTILLES: Saint Martin (ANSP).

***Tricolia affinis pterocladica*, new subspecies**

Plate 144, fig. 3; Plate 145, fig. 3

*Description.* Shell fairly solid, elongate, inflated and reaching 8 mm. in length. The color pattern consists of wavy brown spiral lines which descend from the suture at an angle of about  $45^{\circ}$ . There are usually white lines next to the brown lines. Below the suture and at the periphery there are usually irregular, more or less axial, patches of white. On the body whorl there are 7 or 8 of these. The ground color is light yellowish brown. Occasionally the brown lines break up into dots on the lower part of the body whorl. At the northern end of the range some specimens are red rather than brown. Whorls 5, evenly rounded. Spire produced at an angle slightly less than  $60^{\circ}$ . Protoconch white, minute and depressed. Aperture elongate-ovate. Columellar callus thin. Umbilicus reduced to a minute chink. Suture impressed. Post-nuclear whorls smooth except for minute axial growth lines. Operculum tinged with brown at the margin.

	length	width	
(large)	8.0 mm.	4.6 mm.	Miami Beach, Florida
	4.6	3.1	Holotype, Boynton Beach, Florida
(juvenile)	2.5	1.9	Yamato Rocks, Florida

*Types.* The holotype is in the Museum of Comparative Zoölogy, no. 215662. It was collected by Thomas L. McGinty on March 20, 1957, amongst *Pterocladia* growing on rocks in shallow water at Boynton Beach, Florida. Paratypes are in the Museum of Comparative Zoölogy (no. 215663) and the United States National Museum, at Stanford University, the Academy of Natural Sciences of Philadelphia (nos. 150755, 189846, 195923), the Chicago Natural History Museum (nos. 26483, 53118) and the private collection of T. McGinty.

*Remarks.* This new subspecies can readily be distinguished from the nominate form by the brown (rarely red) color, and, in particular, the color pattern of descending wavy lines. From *T. tessellata*, with which it has been confused, it differs in shape, the spire being higher and the shell growing to a larger size. The spiral lines are far more irregular and descend more rapidly.

At Boynton Beach this subspecies lives amongst the red alga *Pterocladia* (*P. americana* Taylor?) which grows on rocks in shallow water. I am indebted to Mr. Thomas L. McGinty for collecting specimens of this alga and to Dr. William Randolph Taylor for the identification. In the Florida Keys *T. affinis affinis* is known to live on Turtle Grass (*Thalassia*). *Thalassia* does not live north of the Biscayne Bay area on the east coast of Florida (Voss and Voss 1955). As the range of *T. affinis affinis* is coextensive with that of *Thalassia* in southern Florida it is here assumed that *pterocladica* is a geographically segregated ecologic race which is adapted to live on *Pterocladia* rather than on *Thalassia* and hence is able to live farther to the north than the nominate form. The range, however, of *pterocladica* does not coincide with the range of *Pterocladia americana* Taylor (1943). This alga is found from North Carolina and Bermuda to Texas and the Caribbean. It is significant to observe in this connection that the ranges of *T. affinis affinis* and *affinis pterocladica* overlap slightly, the latter appearing sporadically in the northern Florida Keys, and that there is barely any intergradation between the two. It is to be hoped that field studies can be carried out to confirm or modify the suggestions made here on the basis of the preliminary information available. *Tricolia* may possibly not be as dependent on specific plant substrates as here implied.

*Range.* The southeast coast of Florida, from Fort Pierce to the Biscayne Bay area, sporadically as far south as the northern Florida Keys (Grassy Key). Three specimens have also been collected off northwest Florida.

*Specimens examined.* FLORIDA: Fort Pierce (D. and N. E. Schmidt; Mary Godwin); Palm Beach (USNM; ML; G. and M. Kline); NE of Lake Worth, in 45 ft. (FSM); Peanut Id., North Inlet, Lake Worth (T. McGinty); off Lantana, in 10 fathoms (FSM); Boynton Beach (MCZ; T. McGinty; ANSP; CNHM); South Inlet, Lake Worth (MCZ; FSM); Yamato Rocks (MCZ; FSM); Miami Beach (MCZ; ANSP; FSM; USNM; U of M); Miami (MCZ; USNM); Fisher Id., Miami (T. McGinty); Norris Cut (MCZ); Virginia Key (FSM); Bear Cut (D. Moore); Cape Florida, Biscayne Key (FSM); Ragged Keys (USNM); Lower Matecumbe Key (MCZ); Grassy Key (U of M); off Destin, near Fort Walton, in 14 fathoms (T. McGinty).

### ***Tricolia affinis beaufi*, new subspecies**

Plate 144, fig. 4; Plate 145, fig. 5

*Description.* Shell solid, elongate, inflated and reaching 7.5 mm. in length. The color pattern consists of irregular red spiral lines, each bordered by a white line, which descend across the whorls from the suture at an angle of about 40°. The ground color is light pink or pale orange. Below the suture and at the periphery there are red (occasionally brown) patches; often these fuse to form irregular axial stripes. The red lines sometimes break up into dots on the body whorl. Between the red patches below the suture there are often white patches which are sometimes tinged with yellow. On the body whorl

there may be as many as 9 of these. Whorls 6, slightly flattened at the periphery. Spire produced at an angle of  $60^\circ$ . Protoconch minute, white, depressed. Aperture oval. Columellar callus thick, white. Rimately perforate. Suture moderately impressed. Post-nuclear whorls smooth except for minute spiral striae. Operculum fairly thin, white.

length	width	
7.0 mm.	4.8 mm.	Holotype, Barbados, Lesser Antilles
3.2	2.4	Barbados, Lesser Antilles

*Types.* The holotype is in the Museum of Comparative Zoölogy, no. 215664. It was collected by Mrs. F. G. Kellett at Bathsheba, Barbados. Paratypes are in the Museum of Comparative Zoölogy, no. 215665, and in the United States National Museum, the Academy of Natural Sciences of Philadelphia, the American Museum of Natural History, the Chicago Natural History Museum, at Stanford University and the California Academy of Sciences.

*Remarks.* This new subspecies is similar to the red phase of *T. affinis pterocladica* which appears only in the vicinity of Fort Pierce on the southeast coast of Florida. It differs in reaching a larger size, and by having the subsutural patches smaller, more numerous and often tinged with yellow. From the nominate form of the species it differs in having the wavy red spiral lines which descend obliquely across the whorls.

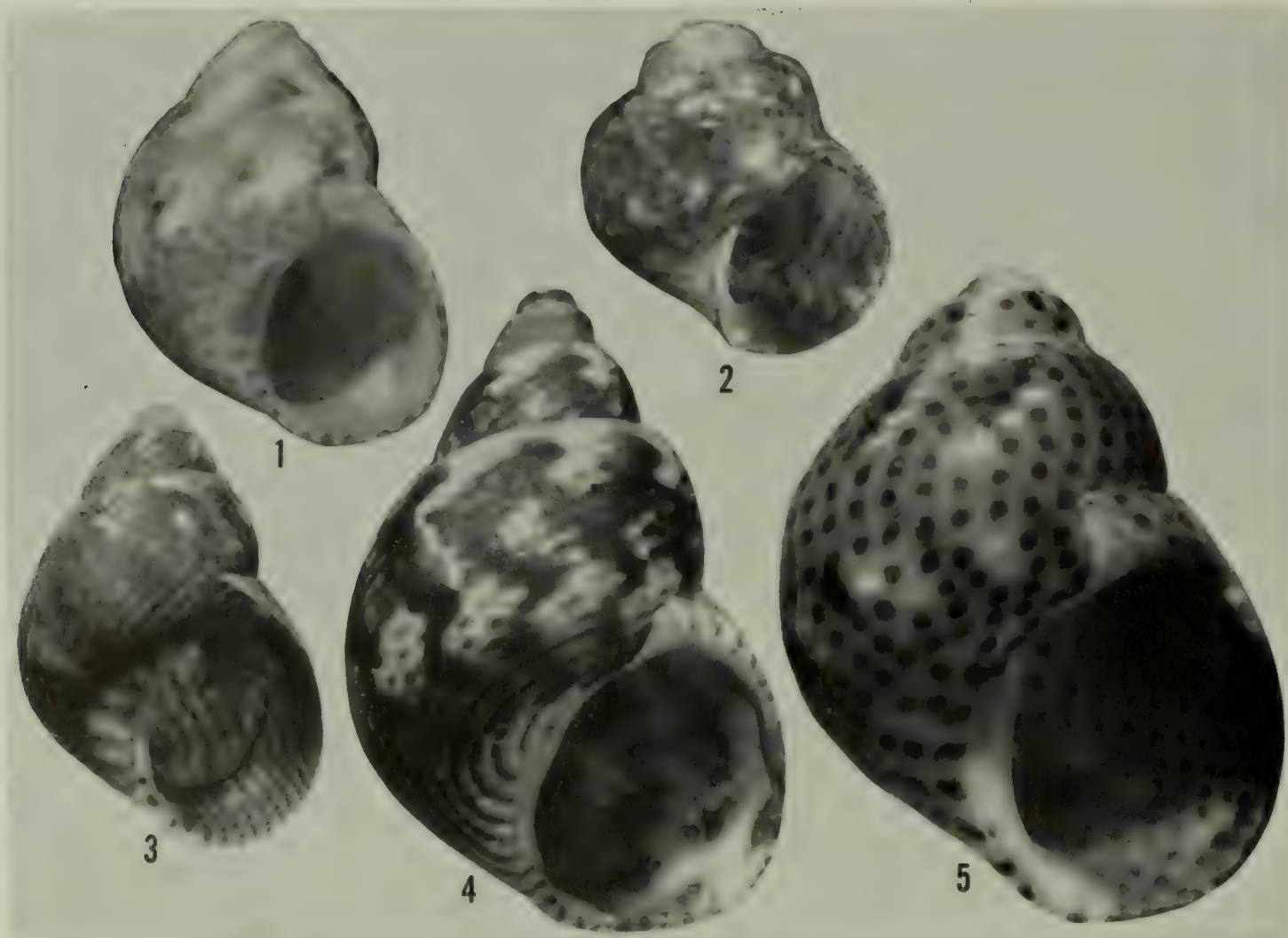


Plate 144. Figs. 1-2. *Tricolia thalassicola* Robertson. Fig. 1. Holotype, near Elbow Cay, Great Abaco Id., Bahama Islands (11.5x). Fig. 2. Deep water form (juvenile), 30 fathoms, off Palm Beach, Florida (22x). Fig. 3. *Tricolia affinis pterocladica* Robertson. Holotype, Boynton Beach, Florida (11x). Fig. 4. *Tricolia affinis beau*i Robertson. Holotype, Bathsheba, Barbados, Lesser Antilles (10x). Fig. 5. *Tricolia affinis cruenta* Robertson. Holotype, Bahia do Flamengo, Ubatuba, São Paulo, Brasil (18x).

The subspecific name is given in memory of Commandant Beau, an ardent collector in Guadeloupe and Martinique over a century ago. It was through his efforts that many of the more interesting marine mollusks of the Lesser Antilles were first discovered. For his obituary see *Journal de Conchyliologie* 7, p. 393, 1858.

*Range.* The Lesser Antilles from Antigua to Tobago.

*Specimens examined.* LESSER ANTILLES: Falmouth and English Harbour, Antigua (USNM); Martinique (AMNH); Bathsheba, Barbados (MCZ); Barbados (USNM: ANSP; LSJU); Pigeon Pt., Tobago (MCZ).

***Tricolia affinis cruenta*, new subspecies**

Plate 144, fig. 5; Plate 145, figs. 4, 6

*Tricolia (Tricolia) pygmaea* 'Philippi' Haas 1953, *Feldiana: Zoology* 34, pp. 204–205 (Ilha Grande, Rio de Janeiro, Brasil); non *Phasianella pygmaea* Philippi 1848.

*Description.* Shell solid, oval, inflated and reaching 6.2 mm. in length. The color pattern consists of rather large more or less square or oblong dark red spots, arranged in regular spiral rows; occasionally some of the spots are white. The ground color is light orange or white, tinged with red. Below the suture and at the periphery there may be irregular white or red axial stripes. The spots are whitish on the white stripes and darker red on the red stripes. Sometimes the subsutural and peripheral stripes fuse. Whorls  $4\frac{1}{2}$ , evenly rounded and smooth. Spire usually produced at an angle of from  $65^{\circ}$  to  $75^{\circ}$ ; apex rounded. Protoconch minute, depressed and white. Aperture oval. Columellar callus fairly thin, white. Umbilicus reduced to a chink. Suture impressed. Operculum dark olive-green at the margin. Two specimens from Pernambuco, Brasil, are unusually elongate, with the spire produced at an angle of about  $50^{\circ}$  (Plate 145, fig. 6). On these specimens the red spots are less regular and have fused in patches here and there.

	length	width	
(large)	6.2 mm.	3.9 mm.	Pernambuco, Brasil
	4.8	3.3	Puerto Cabello, Venezuela
	4.0	3.0	Holotype, Ubatuba, São Paulo, Brasil
	3.2	2.3	Itajaí, Santa Catarina, Brasil

*Types.* The holotype is in the Museum of Comparative Zoölogy, no. 215666. It was collected at Bahia do Flamengo, Ubatuba, São Paulo, Brasil, by W. Narchi on January 7, 1956, and was donated by João de Paiva Carvalho. Paratypes are in the Museum of Comparative Zoölogy, no. 215667, and in the Instituto Oceanográfico, São Paulo, the Academy of Natural Sciences of Philadelphia, and at Stanford University. Paratypes from São Sebastião and Villa Bella, Ilha de São Sebastião, both São Paulo, are in the United States National Museum (nos. 150775, 180790, 364140).

*Remarks.* This new subspecies can be recognized by the regularly spaced large red spots. The spire is usually lower than in other forms of *T. affinis*. It was incorrectly identified by Haas (1953) as *Phasianella pygmaea* Philippi (1848). Philippi described this from an unknown locality and figured it in 1853 (pl. 4, fig. 11). The spire is much higher than is usual in *cruenta*, being produced at an angle of  $55^{\circ}$ , the suture is more

impressed and the aperture is circular rather than oval. Furthermore, the color pattern is entirely different. The red spots are much smaller than in *cruenta* and, in addition, *pygmaea* has large yellow flames below the suture and at the periphery. Pilsbry (1888, p. 284) inadvertently synonymized Philippi's name with *T. tessellata*. The identity of Philippi's species still remains in doubt.

The Brazilian records of *Tricolia concinna* C. B. Adams given by Lange de Morretes (1949) and Gofferjé (1950) are no doubt based on this subspecies.

Specimens from Texas are probably Pleistocene or sub-Recent fossils. Some approach *T. affinis pterocladica* in color pattern.

The subspecific name is a Latin adjective meaning stained or spotted with blood.

*Range.* Along the Caribbean coast of Central and northern South America, ranging as far north as the Grenadines in the Lesser Antilles and south along the coast of Brasil to the State of Santa Catarina. Sporadic on the shores of the western Gulf of Mexico.

*Specimens examined.* TEXAS: Rockport (J. Bequaert); Ransom Island, Aransas Bay (D. Moore). MEXICO: Veracruz (MCZ; ANSP); Dzilam de Bravo (ANSP); Yucatan Channel (USNM). HONDURAS: (USNM; ML). PANAMA: Bocas del Toro, Isla de Colón (T. McGinty; ANSP). COLOMBIA: Cartagena (CAS). CARIBBEAN ISLANDS: Curaçao; Bonaire (both ANSP). VENEZUELA: Puerto Cabello (MCZ). LESSER ANTILLES: Admiralty Bay, Bequia, Grenadines (MCZ); Tobago (USNM); Buccoo Bay, Tobago (ANSP). BRASIL: Fortaleza, Ceará (H. de Souza Lopes); Pernambuco (MCZ); Ponta Verde, Maceió, Alagoas; Itapoan, Salvador, Bahia; Macaé (all H. de Souza Lopes); Ilha Grande (CNHM), both Rio de Janeiro; Bahia do Flamengo, Ubatuba (João de Paiva Carvalho); São Sebastião; Villa Bella, Ilha de São Sebastião; Guarujá, near Santos (all USNM); Santos (H. de Souza Lopes; ANSP), all São Paulo; Cabeçudos, Itajaí, Santa Catarina (H. de Souza Lopes).

### *Tricolia adamsi* Philippi

Plate 143, figs. 3-4; Plate 145, fig. 2

*Phasianella brevis* C. B. Adams 1850, Contributions to Conchology, no. 4, p. 67 (Jamaica); non *P. brevis* d'Orbigny 1842, etc.

*Phasianella adamsi* Philippi 1853, Systematisches Conchylien-Cabinet, Nürnberg, (2) 2, pt. 5, p. 27 [new name for *P. brevis* C. B. Adams 1850, non *P. brevis* d'Orbigny 1842, etc.].

*Eulithidium minutissimum* 'C. B. Adams' Dall 1908, Proceedings United States National Museum 34, p. 255 [*nomen nudum*].

*Description.* Shell fairly thin, subglobose, inflated and reaching 3.8 mm. in length. The color pattern consists of irregularly spaced, rather small, round or oval red dots on a light pink ground color which is partially transparent, except below the suture where it is pure white. The margin of this white area is incised, so that there are lobes of white extending down toward the periphery of each whorl. Between each lobe (of which there are about 8 on the body whorl) the reddish white ground color is intensified. The white subsutural area often becomes obscure on the body whorl. Interspersed between the red dots are a few white dots, except at the periphery. There may also be patches below the periphery where the ground color is darkened. Whorls  $3\frac{1}{2}$  to 4, evenly rounded. Spire low, produced at an angle of from  $76^{\circ}$  to  $85^{\circ}$ ; apex rounded. Protoconch minute, de-

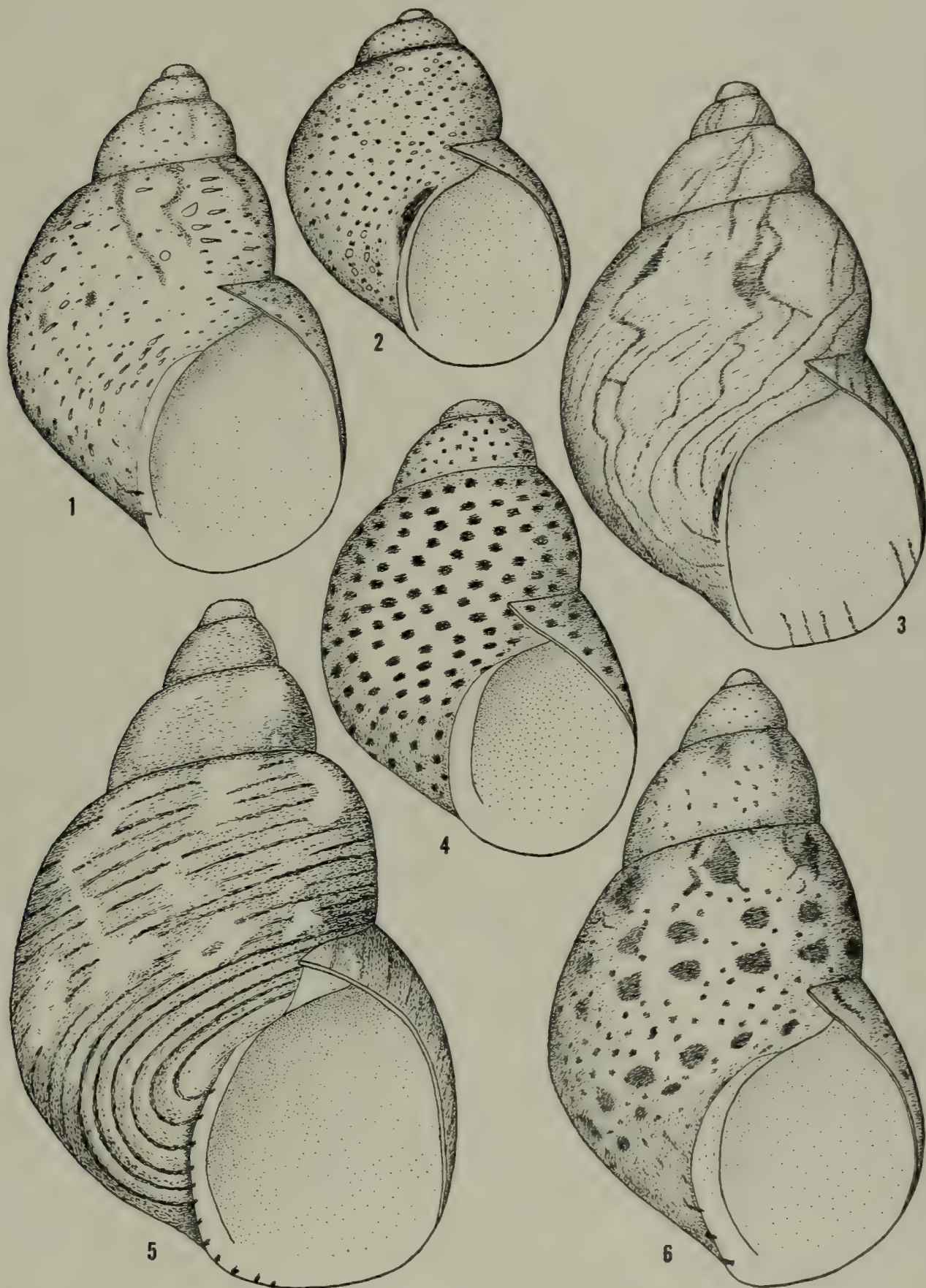


Plate 145. Fig. 1. *Tricolia affinis affinis* C. B. Adams. Great Abaco Id., Bahama Islands. Fig. 2. *Tricolia adamsi* Philippi. Guana Id., Virgin Islands. Fig. 3. *Tricolia affinis pterocladica* Robertson. Miami Beach, Florida. Figs. 4, 6. *Tricolia affinis cruenta* Robertson. Fig. 4. Puerto Cabello, Venezuela. Fig. 6. Elongate form, Pernambuco, Brasil. Fig. 5. *Tricolia affinis beai* Robertson. Barbados, Lesser Antilles (all 13x).

pressed, white or reddish purple. Aperture round to oval. Columellar callus obscure; rimately perforate. Suture impressed. Post-nuclear whorls smooth except for fine spiral striae on the penultimate whorls. Operculum oval, white, strongly convex exteriorly and polished.

	length	width	
(large)	3.8 mm.	3.0 mm.	Guana Id., Virgin Islands
	3.7	2.8	Boca de Congrejos, Puerto Rico
	2.8	2.4	Holotype of <i>Phasianella brevis</i> C. B. Adams
(juvenile)	1.2	1.3	Off Punta Alegre, Camagüey, Cuba

*Types.* Turner (1956, pl. 21, fig. 4) selected a neotype of *Phasianella brevis* C. B. Adams (Plate 143, fig. 4) from St. Thomas, Virgin Islands, believing that the types were lost. This specimen is in the Museum of Comparative Zoölogy, no. 186592. Subsequently a single Jamaican specimen from the C. B. Adams collection has been recovered (Plate 143, fig. 3). Both specimens had been borrowed by Pilsbry from Amherst College before the collection was obtained on exchange by the Museum of Comparative Zoölogy in 1942. The neotype specimen was not returned until after the first paper on C. B. Adams' types was published (Clench and Turner 1950) and the holotype was not returned until after the supplement was published by Turner (1956). The holotype is now in the Museum of Comparative Zoölogy, no. 215661. The neotype as a result is invalid. The type locality is Jamaica.

*Remarks.* This species can be distinguished from *T. affinis affinis*, with which it commonly occurs and has been confused, by the smaller size, the lower spire, and the different color pattern. The white subsutural area of *adamsi* is characteristic and the small red spots are not consistently paired with white spots as they are in *T. affinis affinis*. The present species varies little in color throughout its range. No information is available on its ecology.

Dall (1889a) states that *Phasianella brevis* C. B. Adams "is merely a young specimen of the shell he [C. B. Adams] had previously named *Turbo pulchella*." The specimens seen by Dall must have been misidentified.

Three specimens in the United States National Museum are labeled "*Eulithidium minutissima* C. B. Ads." Although Dall, as indicated in the synonymy above, has referred to this name, it was never published by C. B. Adams.

*Range.* Throughout the West Indies, from the Bahama Islands to the Lesser Antilles, and the coast of Central America (Honduras and Panama). Not present on the coast of Florida.

*Specimens examined.* BAHAMA ISLANDS: Elbow Cay, Great Abaco Id. (R. Robertson); Mangrove Cay, Andros Id. (USNM). Off Nassau Harbour (T. McGinty); Treasure Island (G. and M. Kline); Clifton Bluff (T. McGinty), all New Providence; Campdown, northern Cat Island (MCZ). CUBA: Dimas and Cabañas, Pinar del Río (both USNM); near Habana (ANSP); Arenas de la Chorrera, both Habana; off Punta Alegre, Camagüey; Guantánamo, Oriente (all MCZ). JAMAICA: (MCZ; AMNH; CNHM); Jack's Bay, St. Mary; Port Royal (both USNM). HISPANIOLA: Les Trois Pavillons, Dépt. du Nord-Ouest; Les Cayes; St. Louis du Sud; Aquin, all Dépt. du Sud; Saltrou,

Dépt. de l'Ouest, all Haiti (all USNM); El Canal, Cabo Macorís (MCZ); Bahía de Samaná (USNM), both Dominican Republic. PUERTO RICO: Aguadilla (G. Warmke); Boca de Congrejos (MCZ). VIRGIN ISLANDS: St. Thomas (MCZ; USNM; U of M; CNHM); Guana Id., near Tortola (MCZ); St. Croix (G. Usticke). LESSER ANTILLES: Saint Martin (ANSP); English Harbour, Antigua (USNM); Bathsheba, Barbados (MCZ); Barbados (USNM; ANSP); Buccoo Bay, Tobago (ANSP). HONDURAS: (USNM). PANAMA: Bocas del Toro, Isla de Colón (T. McGinty; ANSP); Colón (LSJU).

***Tricolia thalassicola*, new species**

Plate 142, fig. 2; Plate 144, figs. 1–2; Plate 146

*Phasianella umbilicata* d'Orbigny 1842 [in] Ramon de la Sagra, Histoire de l'Ile de Cuba, Mollusques 2, p. 77, pl. 19, figs. 32–34 (Martinique, Guadeloupe, Jamaica and Cuba) [in part only]; non *Littorina umbilicata* d'Orbigny 1840 [a *Tricolia*].

**Description.** Shell solid, oval, inflated and reaching 7.1 mm. in length. The color pattern consists of a series of regularly spaced, large, light to dark brown, orange or olive-green spots. There are about 7 pairs of axial to oblique flames of color on the body whorl just below the suture and at the periphery; these are the same color as the spots but darker. The spots on the flames are darkened. Between the flames the ground color is cream-white; elsewhere it is cream. The spots are coalesced into oblique spiral bands in some specimens (Plate 146, fig. 3). The spots are occasionally obscure and they then alternate with pale patches. Whorls 6, evenly rounded. Spire usually produced at an angle of from 65° to 77°; apex obtuse. Protoconch minute, depressed and white. Aperture oval. Columella with a white callus. Umbilicus fairly narrow. Suture impressed. Post-nuclear whorls with evenly spaced spiral striae; body whorl smooth except for minute growth lines. Operculum white, strongly convex exteriorly and nearly smooth.

	length	width	
(large)	7.1 mm.	4.5 mm.	Cabo San Antonio, Cuba
	4.3	3.3	Holotype, Great Abaco Id., Bahama Islands
(banded form)	2.9	2.3	Cabañas, Cuba
(deep water form)	2.4	1.8	Off Cape Lookout, North Carolina

**Types.** The holotype is in the Museum of Comparative Zoölogy, no. 213260. It was collected by the author at Johnnie's Cay, Drunken Cays, near Elbow [Little Guana] Cay, Great Abaco Id., Bahama Islands, on July 28, 1953. Paratypes from the vicinity of Elbow Cay are in the Museum of Comparative Zoölogy, no. 213261, the United States National Museum, the Academy of Natural Sciences of Philadelphia, the American Museum of Natural History, the Chicago Natural History Museum, at Stanford University, the California Academy of Sciences, the Institute of Marine Biology, Puerto Rico, and the private collection of Thomas L. McGinty.

**Remarks.** This species has been called *Phasianella umbilicata* d'Orbigny. However, d'Orbigny's figure and part of his description were based on *T. affinis affinis*. Unfortunately, the seven syntypes in the British Museum (Natural History) [no. 54.10.4.283] are *thalassicola* (one is figured here, Plate 142, fig. 2). The specimen figured originally by d'Orbigny is evidently lost. It was deemed wiser to describe the present species as new

rather than merely to rename d'Orbigny's homonym after selecting the syntype figured here as the lectotype. These syntypes hence become invalid.

The species can readily be distinguished from *T. affinis* and *T. adamsi*, with which it has been confused, by the regularly spaced brown, orange, or olive-green spots, which are relatively much larger than the red and the white spots of both these other species. Also, *T. affinis* is more elongate and grows to a larger size. The whorls of *thalassicola* are more rounded, and the early whorls are evenly spirally striated, while in *T. affinis* they are smooth.

In a rare color form of *thalassicola* the spots are coalesced so that the color pattern consists of broad yellowish brown obliquely spiral bands on a cream ground color (Plate 146, fig. 3). This form has been referred to as *T. tessellata*, but it is clearly distinguishable by the shape of the shell, the spirally striated initial whorls and the thickness of the obliquely spiral bands of color. Sometimes some of the spots near the base of the columella do not coalesce, showing that this is merely a color form differing in no significant way from the spotted form. It occurs sporadically in shallow water along the Florida Keys and in the Caribbean.

A deep water form (Plate 144, fig. 2; Plate 146, fig. 2) occurs at both the northern and southern ends of the range—North Carolina and Brasil—as well as off southern, western, and northwestern Florida and off Yucatán, all in depths of from 10 to 35 fathoms. Empty shells have been dredged as deep as 117 fathoms. This form was erroneously identified by Dall, in part, as *Phasianella brevis* d'Orbigny, an entirely different species, here referred to the genus *Gabrielona*. The deep water form is much smaller than the shallow water forms of *thalassicola*. The suture is more impressed and the whorls are more inflated. The characteristic spots of *thalassicola* are much smaller but are similarly arranged, often with axial to oblique stripes below the suture and at the periphery. The initial whorls are spirally striated as in the shallow water forms. This deep water form may possibly be a species distinct from *thalassicola* but its discontinuous and peripheral distribution suggests that this is not the case.

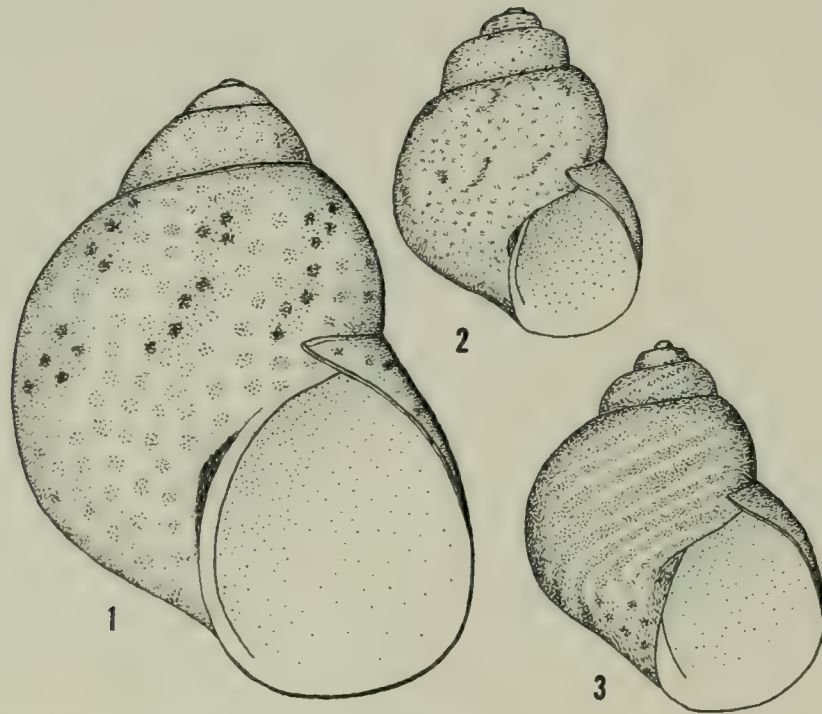


Plate 146. *Tricolia thalassicola* Robertson. Fig. 1. Great Abaco Id., Bahama Islands. Fig. 2. Deep water form, off Cape Lookout, North Carolina. Fig. 3. Banded form, Cabañas, Pinar del Río, Cuba (all 13x).

This species normally lives on Turtle Grass (*Thalassia testudinum* König). The specific name is derived from this fact. It may feed on the *Thalassia* itself, or, which is more likely, on the epiphytic algae. Little information has been published on the distribution of *Thalassia* in the Western Atlantic except that by Ostenfeld (1927) and by Voss and Voss (1955) on Florida. It does not live off North Carolina and it is unlikely that it would grow in water deeper than 10 fathoms, so the deep water form of *thalassicola* probably lives in another habitat. *Thalassia* does not live in Lake Worth, Florida, yet specimens of *thalassicola* have been collected there, but they are small and do not show the color pattern of spots clearly. The large specimens with prominent spots, so abundant in the Bahama Islands and along the north coast of Cuba, live invariably on *Thalassia*. They have been dredged in shallow water to a depth of 5 fathoms, being most abundant where the sediment is calcareous. Variation in this species is probably due in part to different plant foods.

*Range.* From off Cape Hatteras, North Carolina, throughout the West Indies, to off Cabo de São Roque, Rio Grande do Norte, Brasil. There are no records from the western half of the Gulf of Mexico and the Atlantic coast of Central America and Colombia. *Thalassia*, however, does live in these areas.

*Specimens examined.* NORTH CAROLINA: *Albatross*, station 2596 (N. Lat. 35°08'30"; W. Long. 75°10'00") in 49 fathoms (dead); *Albatross*, station 2595 (N. Lat. 35°08'00"; W. Long. 75°05'30") in 63 fathoms (dead), both off Cape Hatteras; *Albatross*, station 2617 (N. Lat. 33°37'30"; W. Long. 77°36'30") in 14 fathoms (dead), off Cape Lookout (all USNM). FLORIDA: off Palm Beach in 30 fathoms (T. McGinty); Boynton Beach (ANSP; T. McGinty); *Eolis*, stations 49, 51, 70, 113, 124, in 10–35 fathoms, all off Miami (all USNM); Fisher Id., Miami (T. McGinty); *Eolis*, stations 8, 105, 107, 123, 142, 150, 306, in 22–100 fathoms (all dead), all off Fowey Light (all USNM); Turtle Harbor (ANSP; U of M); *Eolis*, station 59, in 20 fathoms (dead), off Turtle Harbor (USNM); off Carysfort Light, in 66–117 fathoms (dead); off The Elbow, Key Largo, in 66–75 fathoms (dead; both MCZ); Upper Matecumbe Key (USNM); Conch Keys (T. McGinty); off Sombrero Light, in 58 fathoms (dead; MCZ); Key West; *Eolis*, station 44, in 50 fathoms (dead), off Key West (both USNM); Garden Key (FSM); Loggerhead Key (USNM; FSM; T. McGinty), both Dry Tortugas; 90 miles SW of Egmont Key, S of St. Petersburg, in 70 fathoms (dead); off Destin, near Fort Walton, in 14 fathoms (dead; both T. McGinty). BAHAMA ISLANDS: N of Little Abaco Id. (MCZ); Drunken Cays, Elbow [Little Guana] Cay and Tilloo Cay, Great Abaco Id. (all R. Robertson); Sweetings Village, Great Abaco Id. (MCZ); Great Isaac (U of M); 10 miles NE of North Point, North Bimini (R. Robertson); North Bimini and South Bimini (both USNM); off Gun Cay (U of M); South Cat Cay (USNM; T. McGinty), all Bimini Ids.; South Riding Rock (R. Robertson); Mangrove Cay, Andros Id. (MCZ; USNM); Lyford Cay, S of North Cay in 2 fathoms and off Nassau Harbour (all T. McGinty); North Cay (CNHM), all New Providence Id.; Galloway Landing, Long Id.; Matthew Town, Great Inagua Id. (both MCZ). CUBA: Cabo San Antonio; Punta del Tolete, in 2–3 fathoms; off Los Arroyos; Dimas, in 4–5 fathoms; Santa Lucía, in 2–4 fathoms; La Esperanza, in 2–3 fathoms; Cayo Arenas, in 2 fathoms; Cayo Levisa, in 2–3 fathoms; Punta Colorado, in 2–3 fathoms; Cabañas, all Pinar del Río (all USNM);

Arenas de la Chorrera, Habana: Bahía de Matanzas: *Atlantis*, station 2993 (N. Lat. 23°24'; W. Long. 80°44') in 580 fathoms (dead), off Bahía de Cárdenas, both Matanzas: off Cayo Fragoso, Las Villas: off Punta Alegre, Camagüey: Guarda la Vaca, near Puerto Samá, Oriente (all MCZ). CAYMAN ISLANDS: Grand Cayman (MCZ; ANSP). JAMAICA: Montego Bay, St. James: Port Antonio, Portland (both USNM). HISPANIOLA: Bariadèle: Les Cayes: Ile-à-Vache, all Dépt. du Sud, Haiti (all USNM); Montecristi (MCZ; ANSP); Bahía de Samaná (USNM), both Dominican Republic. PUERTO RICO: Vieques (USNM). VIRGIN ISLANDS: St. Thomas (USNM; ANSP): St. John (MCZ). LESSER ANTILLES: Saint Martin (ANSP): Falmouth and English Harbour, Antigua: Carlisle Bay, Barbados (all USNM): Admiralty Bay, Bequia, Grenadines (MCZ). CARIBBEAN ISLANDS: Curaçao (USNM; ANSP). MEXICO: Dzilam de Bravo (ANSP): off Cabo Catoche (USNM), both Yucatán. BRASIL: *Albatross*, station 2758 (S. Lat. 6°59'30"; W. Long. 34°47'00") in 20 fathoms, off Cabo de São Roque, Rio Grande do Norte (USNM).

### *Tricolia bella* M. Smith

Plate 139, fig. 5: Plate 142, figs. 4-5; Plate 143, fig. 5; Plate 147, figs. 1-2

*Turbo* (?) *pulchellus* C. B. Adams 1845, Proceedings Boston Society of Natural History 2, p. 7 (Jamaica); non *Phasianella pulchella* Récluz 1843 [a *Tricolia*].

*Littorina adamsii* Reeve 1857, Conchologia Iconica 10, *Littorina*, no. 85 (Jamaica) [“*Littorina pulchella*, C. B. Adams, MS., Mus. Cuming” cited as a synonym]; non *Phasianella adamsi* Philippi 1853 [a *Tricolia*].

*Phasianella bella* ‘Pilsbry’ M. Smith 1937, East Coast Marine Shells, p. 81, pl. 31, fig. 20 [new name for *Tricolia pulchella* C. B. Adams 1845, non Récluz 1843, in Pilsbry’s MS. This is listed as a synonym of *bella* by Maxwell Smith].

*Description.* Shell solid, conical, more or less carinate, with spiral cords and reaching 5.2 mm. in length. The color pattern consists of red, pink, brown or orange-yellow spots or flames on a white ground color. Sometimes the shell is greenish or khaki-colored: rarely it is unicolored. The flames usually form irregular axial stripes and the spots are usually delimited by the width of the spiral cords. Whorls  $4\frac{1}{2}$  to 5, angular in the middle, with the body whorl biangular, or rounded. Spire produced at an angle of from 59° to 64°. Protoconch fairly large and prominent, flattened apically and either white or bright purple. Aperture nearly round. Columellar callus obscure. Rimately perforate. Suture impressed. The keel above the periphery is usually strongly developed while the keel below on the body whorl is always less prominent: both are usually spotted with white. Above and below these keels and between them there are fine irregularly beaded spiral cords. In a smooth form of the species (Plate 147, fig. 2) the initial whorls are threaded but on the evenly rounded body whorl the cords are obscure and the keels are replaced by stripes on which the color pattern differs from that on the remainder of the whorl. The upper keel can always be seen on the early post-nuclear whorls. The operculum is round-ovate, white, externally convex and threaded near the margin. The juvenile operculum is perforate (Plate 139, fig. 5).

	length	width	
(smooth form)	5.2 mm.	3.3 mm.	Miami Beach, Florida
	4.3	3.0	St. Thomas, Virgin Islands
	3.0	2.3	Lectotype of <i>Turbo</i> (?) <i>pulchellus</i> C. B. Adams
(juvenile)	0.7	0.6	Pigeon Cays, Andros Id., Bahama Islands

**Types.** The lectotype of *Turbo* (?) *pulchellus* C. B. Adams (Plate 143, fig. 5), selected by Clench and Turner (1950, pl. 40, fig. 9), is in the Museum of Comparative Zoölogy, no. 156358. Lectoparatypes from Jamaica are in the Museum of Comparative Zoölogy (no. 186165), the Academy of Natural Sciences of Philadelphia (no. 6453) and the United States National Museum (no. 64386). Two syntypes of *Littorina adamsii* Reeve (Plate 142, figs. 4-5) are in the British Museum (Natural History), nos. 1957.6.3.4-5. The type locality is Jamaica.

**Remarks.** This species can readily be identified by its characteristic shape. It was identified by Pilsbry (1888, pl. 39, fig. 95), in part, as *Phasianella umbilicata* d'Orbigny, a name here discussed in the *Remarks* on *T. thalassicola*.

Maxwell Smith unintentionally renamed C. B. Adams' homonym by using Pilsbry's manuscript name. The specimen he figures and describes is the smooth form from Florida.

The smooth form of this species (Plate 147, fig. 2) occurs with, and intergrades with, the ribbed form and is most abundant from Miami to the Florida Keys and in parts of the Bahama Islands, but also appears occasionally on the north coast of Cuba, on the east coast of Guatemala and in the Lesser Antilles at Antigua. Even where it occurs the smooth form is not uniformly distributed, for at many localities in the Florida Keys and in the Bahama Islands only the ribbed form has been collected.

A specimen of the smooth form was collected by the author at Great Abaco Id., Bahama Islands, on *Thalassia* in shallow water. These two variants are not ecologic forms, however, because the ribbed form also lives on *Thalassia*, as well as in a variety of other habitats, such as in calcareous gravel and beneath gorgonian holdfasts. The dimorphism is probably entirely genetic. In general, the specimens mottled with green or khaki (both smooth and ribbed forms) live on *Thalassia*, while those spotted with red are found elsewhere.

**Range.** From Lake Worth south along the east coast of Florida, throughout the Florida Keys and the West Indies, west to the coast of Central America and south at least to the State of Alagoas, Brasil. Dall (1892) records the species from the Cedar Keys on the west coast of Florida and as a Pliocene fossil in South Carolina.

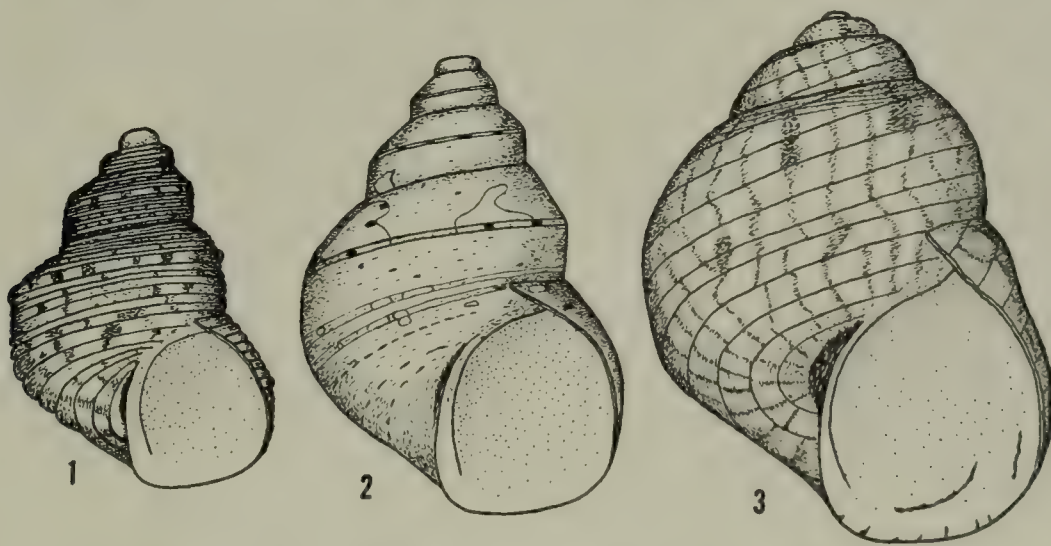


Plate 147. Figs. 1-2. *Tricolia bella* M. Smith. Great Abaco Id., Bahama Islands. Fig. 1. Ridged form. Fig. 2. Smooth form. Fig. 3. *Tricolia tessellata* Potiez and Michaud. Barbados, Lesser Antilles (all 13x).

*Specimens examined.* FLORIDA: North Inlet (T. McGinty); South Inlet (MCZ), both Lake Worth; Bakers Haulover, Miami (ANSP); Miami Beach (ANSP; FSM); off Government Cut, Miami; *Eolis*, stations 49, 51, 70, in 10–30 fathoms (dead), off Miami (all USNM); Fisher Id., Miami (T. McGinty); Ragged Keys; *Eolis*, station 366, in 75–90 fathoms (dead), east of Ragged Keys; *Eolis*, stations 8, 80, 306, in 25–100 fathoms (dead), off Fowey Light (all USNM); Sands Key, Biscayne Bay (MCZ; USNM); Caesars Creek Bank, north of Key Largo (USNM); Key Largo (LSJU); Turtle Harbor, in 4–10 fathoms; Upper Matecumbe Key (both USNM); Teatable Key (T. McGinty); Indian Key (USNM); Lower Matecumbe Key (USNM; CAS); Center Key (LSJU); Conch Keys (T. McGinty; ANSP); Grassy Key (ANSP); Bonefish Key (MCZ; ANSP; CNHM; LSJU; U of M; FSM); Little Duck Key; Missouri Key (both MCZ); Bahia Honda Key (USNM; ANSP); Noname Key (LSJU); Big Pine Key (MCZ; ANSP); Newfound Harbor Key (USNM); Torch Key (ANSP); Summerland Key (D. and N. E. Schmidt); Loggerhead Key (USNM); Sugarloaf Key; Boca Chica Key (both ANSP); Middle Sambo Shoals, S of Boca Chica Key (T. McGinty); Key West (MCZ; USNM; ANSP; LSJU; U of M); Boca Grande Key (USNM); Garden Key (USNM; FSM); Loggerhead Key (USNM; T. McGinty); Sand Key; Bush Key (both FSM), all Dry Tortugas. BAHAMA ISLANDS: N of Little Abaco Id.; Whale Cay Channel; Sweetings Village, both Great Abaco Id. (all MCZ); Elbow [Little Guana] Cay; between Channel Cay and Wilson City, both Great Abaco Id. (both R. Robertson); Great Isaac (U of M). 5 miles NE of North Point, North Bimini (R. Robertson); North Bimini (USNM); South Bimini (MCZ; USNM); South Cat Cay (USNM; T. McGinty), all Bimini Ids.; South Riding Rock; Deep Creek, Andros Id. (both R. Robertson); Pigeon Cays (T. McGinty) and Mangrove Cay (MCZ; USNM), Andros Id.; Clifton Pt., Lyford Cay, S of North Cay, and off Nassau Harbour, all New Providence Id. (all T. McGinty); Simms; Galloway Landing, both Long Id. (both MCZ); Acklins Id. (USNM). CUBA: off Los Arroyos; Dimas; Cayo Arenas; Cayo Levisa; Bahía Honda; Cabañas, all Pinar del Río (all USNM); Arenas de la Chorrera, Habana (MCZ; CNHM); Bahía de Matanzas; Varadero (both MCZ); Bahía de Cárdenas (USNM), all Matanzas; off Cayo Frágoso, Las Villas; off Punta Alegre, Camagüey; Guarda la Vaca, near Puerto Samá; Guantánamo, both Oriente (all MCZ). JAMAICA: Montego Bay, St. James; Jack's Bay, St. Mary (both USNM); Port Royal (MCZ; USNM); Mouth of Rio Cobre, St. Catherine (USNM). HISPANIOLA: Les Trois Pavillons, Dépt. du Nord-Ouest; Bariadèle; Coteaux; Les Cayes; Aquin, all Dépt. du Sud; Saltrou, Dépt. de l'Ouest, all Haiti (all USNM); Montecristi; Puerto Plata; El Canal, Cabo Macorís (all MCZ); Bahía de Samaná (USNM), all Dominican Republic. PUERTO RICO: Rincón (LSJU); Aguadilla; Boca de Congrejos (both G. Warmke). VIRGIN ISLANDS: St. Thomas (USNM; ANSP); St. Croix (G. Usticke). LESSER ANTILLES: Falmouth and English Harbour, Antigua (USNM); Martinique (AMNH); Crane Pt., Barbados (USNM); Barbados (MCZ; ANSP; LSJU); Pigeon Pt. (MCZ); Buccoo Bay (MCZ; ANSP), both Tobago. GUATEMALA: Livingston and Puerto Barrios (ANSP). HONDURAS: Isla Utila (USNM). PANAMA: Bocas del Toro, Isla de Colón; Piña, west of Colón; Colón (all T. McGinty). BRASIL: Maceió, Alagoas (H. de Souza Lopes).

**Tricolia tessellata Potiez and Michaud**

Plate 142, fig. 3; Plate 143, fig. 6; Plate 147, fig. 3

*Phasianella tessellata* 'Beck' Potiez and Michaud 1838, Galerie des Mollusques, Paris, 1, p. 312, pl. 29, figs. 7-8 (Martinique).

*Phasianella minuta* Anton 1839, Verzeichniss Conchylien, Halle, p. 60; non *P. minuta* J. Sowerby 1817 [is a synonym of *P. tessellata* Potiez and Michaud according to Philippi 1853, p. 19].

*Phasianella zebrina* d'Orbigny 1842 [in] Ramon de la Sagra, Histoire de l'Ile de Cuba, Mollusques 2, p. 78, pl. 19, figs. 35-37 (Guadeloupe).

*Phasianella tessellata* C. B. Adams 1850, Contributions to Conchology, no. 4, pp. 67-68 (Jamaica) [misspelled *tesselata* in republication by Clench and Turner 1950, p. 351].

*Phasianella lipeata* 'Dkr.' Krebs 1864, The West-Indian Marine Shells, p. 79 (republished by Clench, Aguayo and Turner 1947, Revista de la Sociedad Malacológica 5, p. 109) [*nomen nudum*; cited as a synonym of *P. tessellata* C. B. Adams "according to specimens in the collection of A. H. Riise"].

**Description.** Shell solid, smooth, oval, inflated and reaching 5.2 mm. in length. The color pattern consists of regularly spaced spiral lines which descend obliquely, arising from the suture at an angle of about  $15^{\circ}$ . There are irregular axial streaks between these, often in subsutural and peripheral patches. The lines and streaks are red or brown (sometimes with an olive-green tint) on a pale cream or pink ground color with irregular white spots adjacent to them. The entire shell is sometimes brownish black, with the oblique spiral lines darkest. Whorls 5, convex, slightly flattened or even concave above the periphery. Apex obtuse and the spire produced at an angle of from  $72^{\circ}$  to  $76^{\circ}$ . Protoconch minute, red or purple. Aperture oval. Columella with a white callus. Umbilicus narrow. Suture slightly impressed. Body whorl often spirally striated, the striae deepest just below the suture. Operculum white, tinged marginally with dark green and brown, spirally striated internally; radially striated externally, most strongly near the margin.

	length	width	
	5.2 mm.	4.5 mm.	Jamaica
	3.7	3.0	Barbados
(juvenile)	1.5	1.4	Aquin, Haiti

**Types.** According to Gaillard (in Kaas, Basteria 21, p. 84, 1957) the Potiez and Michaud types formerly in the Musée de Douai, Dépt. du Nord, France, have disappeared. Hence there are now no type specimens of *Phasianella tessellata* Potiez and Michaud. The whereabouts of Anton's types is unknown to the author. Seven syntypes of *Phasianella zebrina* d'Orbigny (one is illustrated here, Plate 142, fig. 3) are in the British Museum (Natural History), no. 54.10.4.284. The lectotype of *Phasianella tessellata* C. B. Adams (Plate 143, fig. 6), selected by Clench and Turner (1950, pl. 36, fig. 12), is in the Museum of Comparative Zoölogy, no. 186067. Lectoparatypes from Jamaica are in the Museum of Comparative Zoölogy (nos. 119308, 186068), the Academy of Natural Sciences of Philadelphia (no. 6463) and in the United States National Museum (nos. 6418, 54762, 64387). The type locality of *P. tessellata* Potiez and Michaud is Martinique, Lesser Antilles.

**Remarks.** This abundant species is easily recognized by the oblique spiral lines and the shape of the shell. It is highly variable in coloration: some specimens are red, others are light brown and a few are brownish black. The light brown form is abundant in Jamaica

but decreases in frequency to the east and south. In the Lesser Antilles where the red form is abundant the brown form is scarce. The red form is infrequent in Jamaica. The brownish black form appears sporadically throughout the range. Specimens from Venezuela, Colombia and Panama are of all three color forms and are strongly pigmented.

The differences between the present species and the banded form of *T. thalassicola* are discussed in the *Remarks* under the latter species.

Records of this species in Florida are based on *T. affinis pterocladica*.<sup>1</sup> No specimens have been seen by the author from the Bahama Islands,<sup>2</sup> Cuba or the northern portion of Haiti. It probably does not live in these areas. The Brazilian record of *Tricolia minuta* Anton given by Lange de Morretes (1949), which presumably is based on this species, is questionable.

*Range.* Jamaica, Hispaniola, Puerto Rico, south through the Lesser Antilles to Trinidad and west along the coast of northern South America to Panama.

*Specimens examined.* JAMAICA: Montego Bay, St. James; Jack's Bay, St. Mary; Port Morant, St. Thomas (all USNM); Port Royal (MCZ; USNM); Mouth of Rio Cobre; Old Harbour, both St. Catherine (both USNM). HISPANIOLA: Port Salut; Torbeck; Les Cayes; St. Louis du Sud; Aquin, all Dépt. du Sud; Saltrou, Dépt. de l'Ouest, all Haiti (all USNM). Montecristi (MCZ; ANSP); Puerto Plata; El Canal, Cabo Macorís (both MCZ); Bahía de Samaná (USNM), all Dominican Republic. PUERTO RICO: Aguadilla (G. Warmke); Arecibo; Boca de Congrejos (both MCZ); Guaniquilla (LSJU); Mayagüez (USNM); off Mayagüez, in 40–100 ft.; Rincón (both G. Warmke); Rincón Lighthouse; Bahía de Añasco; Pta. Arenas, Vieques (all MCZ). VIRGIN ISLANDS: St. Thomas (USNM; AMNH); Guana Id., near Tortola (MCZ); St. Croix (G. Usticke). LESSER ANTILLES: Saint Martin (ANSP); Falmouth, Antigua (USNM); Guadeloupe (MCZ; ANSP); Martinique (AMNH); Bathsheba, Barbados (MCZ; USNM); Barbados (ANSP; AMNH; LSJU; CNHM); Anse Fourmi, Tobago; Carenage, Trinidad (both MCZ). VENEZUELA: Maiquetía, Federal District (ANSP). COLOMBIA: Cartagena (CAS). PANAMA: Bocas del Toro, Isla de Colón (T. McGinty).

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<sup>1</sup> M. Smith (1937) identified both species as *tessellata*. One of the specimens he illustrates is *T. affinis pterocladica* (pl. 29, fig. 18a) and the other is true *tessellata* (pl. 29, fig. 18b). The latter could not have been collected in Florida.

<sup>2</sup> Ford's record (1944) is erroneous.

### Notes

The synonymies are given here of two Eastern Pacific species which are the types of *Eulithidium* Pilsbry and *Usatricolia* Habe, here considered synonyms of *Tricolia*, s.s.

#### *Tricolia variegata* Carpenter Plate 138, fig. 6; Plate 148, fig. 1

*Eucosmia variegata* Carpenter 1864, Annals and Magazine of Natural History (3) 13, p. 475 (Cape San Lucas [Baja California, Mexico]).

*Eulithidium typicum* Dall 1908, Proceedings United States National Museum 34, p. 255 [new name for *Eucosmia variegata* Carpenter 1864, non *Phasianella variegata* Lamarck 1822].

*Phasianella (Eulithidium) typica* Dall. Strong 1928, Proceedings California Academy of Sciences (4) 17, p. 194, pl. 10, figs. 12-13.

This species is the type of *Eulithidium* Pilsbry. It is to be observed that the spire is not particularly low. It is known only from Cape San Lucas and Bahía Magdalena, Baja California, Mexico. The holotype is in the United States National Museum, no. 11836.

#### *Tricolia compta* Gould Plate 138, fig. 4; Plate 148, fig. 2

*Phasianella compta* Gould 1855, Appendix to the Preliminary Geological Report of William P. Blake (Palaeontology). Explorations and Surveys for a Railroad Route from the Mississippi River to the Pacific Ocean (War Department), U.S. House of Representatives Doc. 129, 33d. Congress, 1st. Session, pp. 22, 25 (San Diego, California) [published as a separate but not included in the Congressional Reports]; 'Gould, ms.' Carpenter 1856 (May), Catalogue of the Reigen Collection of Mazatlan Mollusca in the British Museum, pp. 225-226 (San Diego and Santa Barbara, California; Mazatlan, Mexico); 'Gould, MS.' Carpenter 1857 (January 7), Proceedings Zoological Society of London 24, p. 204 (Santa Barbara and San Diego); Gould 1857, Pacific Railroad Reports 5, pt. 2, pp. 330, 333-334, pl. 11, figs. 25-26 (San Diego).

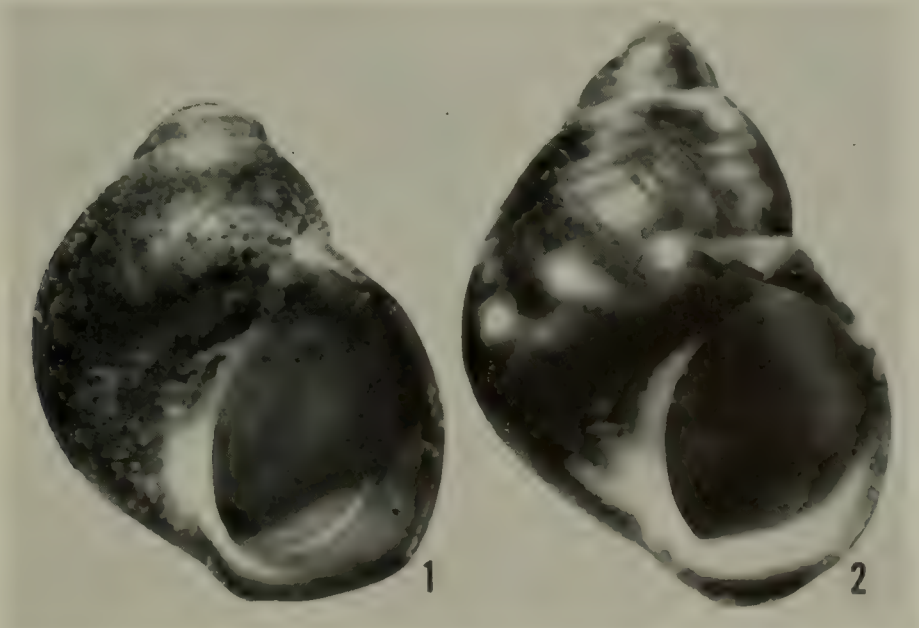


Plate 148. Fig. 1. *Tricolia variegata* Carpenter. Bahía Magdalena, Baja California, Mexico (21x). The type species of *Eulithidium* Pilsbry. Specimen collected and identified by A. M. Strong (CAS Loc. 24036). Fig. 2. *Tricolia compta* Gould. Ideotype, Santa Barbara, California (11x). The type species of *Usatricolia* Habe.

*Phasianella (Tricolia) compta* Gould var. *producta* Dall 1908, Proceedings United States National Museum **34**, p. 256 [refers to Pilsbry 1888, pl. 39, fig. 69].

*Phasianella (Tricola) compta* Gould. Strong 1928, Proceedings California Academy of Sciences (4) **17**, p. 191, pl. 10, fig. 1.

This species is the type of *Usatricolia* Habe. It is apparently restricted to the coast of California and northern Baja California. The specimen figured is an ideotype mentioned by Carpenter from Santa Barbara. The location of Gould's holotype of this species is unknown. According to Palmer (1951) two specimens from Mazatlan ("Tablet 1086" listed by Carpenter in 1856) are in the New York State Museum. These are probably a different species.

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### *Phasianella bicarinata* Poulsen

*Phasianella bicarinata* 'd'Orbigny' Poulsen 1878, Catalogue of West-India Shells, Copenhagen, p. 13 [*nomen nudum*]; non *P. bicarinata* Dunker 1846.

This was probably a misidentification of *Tricolia bella*. *T. bicarinata* Dunker is a similar South African species.

### *Phasianella concolor* C. B. Adams

*Phasianella concolor* C. B. Adams 1850, Contributions to Conchology, no. 4, p. 68 (Jamaica).

This is a synonym of *Assiminea auberiana* (d'Orbigny), as was first shown by Dall (1892). The lectotype, selected by Clench and Turner (1950, pl. 36, fig. 3), is in the Museum of Comparative Zoölogy, no. 186022; so also are lectoparatypes, no. 186023. Pilsbry (1888, pp. 171, 275, pl. 45, fig. 1) erroneously applied this name to the dark brown form of *Tricolia tessellata*.

### *Phasianella tessellata* Anton

*Phasianella tessellata* Anton 1839, Verzeichniss Conchylien, Halle, p. 61 (South America); non *P. tessellata* Potiez and Michaud 1838.

As suggested by Philippi (1853, p. 32) this is probably a *Littorina*.

\* \* \* \*

Dall (1889b) records both "*Phasianella umbilicata* Orbigny" and "*P. pulchella* C. B. Adams" [= *Tricolia bella* M. Smith] from Bermuda. Two species of *Tricolia* are also listed from the island by Tristram (1862). I have seen no authentic Bermuda specimens.

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\* \* \* \*

## The Museum Boltenianum or the Bolten Catalogue

Probably no one book and particularly one so small has brought forth so much comment or caused so much controversy in the field of malacology as the 199 page catalogue of the Museum Boltenianum which was published in 1798. The Bolten Catalogue, as it is commonly called, was originally a manuscript classification which Dr. J. F. Bolten of Hamburg, Germany, had worked out for his large shell collection. It is believed that he had intended to publish his system of classification but he died before it was completed. Later, P. F. Röding, a book dealer and student of malacology, added to the manuscript references to Gmelin 1791, the *Conchylien-Cabinet* and other publications in order that the names might be identified. This was done at the request of the family and the catalogue was published and offered for sale, partly as a tribute to the late Doctor but also with the hope that the collection would be purchased as a unit by some museum or scholar. Dr. Bolten had disagreed with much that had been done in malacology up to that time and so, diverging greatly from the Linnean system, instituted a multitude of

new generic and specific names. Thus the catalogue consists simply of a list of genera and species with references to other publications.

Though offered for sale, the catalogue apparently was not widely distributed and was little used, and Lamarck's classification and names which were published in 1799 were followed for many years. Of the early workers who referred to the Museum Boltenianum, O. A. Mörch and H. and A. Adams were the most important. It was in 1906 that Dall brought the Museum Boltenianum to the fore and in the same year Sherborn and Sykes brought out a photographic facsimile of the catalogue, thus making it more available. This was followed by a lively discussion as to whether or not the catalogue was truly a publication or only a sales catalogue, and an equally ardent controversy waged concerning the author—was it Bolten or Röding? It is generally considered today that since it was Röding who added the necessary references to identify Bolten's names he should be considered the author.<sup>1</sup> When in 1926 the International Commission on Zoological Nomenclature made a ruling (Opinion 96) that the Museum Boltenianum was an acceptable publication in systematic zoology, the names instituted in it had priority over those of Lamarck and several other workers. Consequently many old and well-known names were put into synonymy and most malacologists, following the ruling of the Commission, set themselves to the task of revising various groups, using Röding's names. Now, after more than 30 years of recognition, the names instituted in the Museum Boltenianum have come into general use.

The following partial bibliography is given for those who wish to go further into the history and discussion concerning this famous little book.

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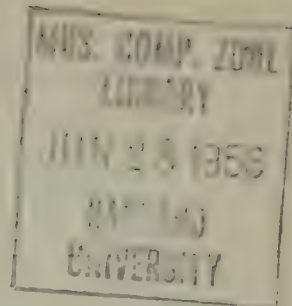
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<sup>1</sup> Article 21, International Rules of Zoological Nomenclature (1905).

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PINNIDAE

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## THE FAMILY PINNIDAE IN THE WESTERN ATLANTIC

BY

RUTH D. TURNER AND JOSEPH ROSEWATER

The Pinnidae is a small family of highly specialized bivalves which belongs to the order Anisomyaria, that is, bivalves which have a large posterior adductor muscle, while the anterior adductor is small or lacking. They are world-wide in distribution in warm-temperate and tropical seas. Most species are found in sandy and muddy areas, from the low water line to depths of about 10 to 25 fathoms. They are wedge- or fan-shaped bivalves which are equivalve but inequilateral. The umbos are terminal and are located at the very narrow, anterior end which is buried in the substratum. Young specimens, at the time of settling, are normal, equilateral bivalves as is shown in Plate 150, figs. 1-6. However, as growth is almost entirely in a posterior direction, the shell very quickly becomes triangular in shape and the umbos become terminal. As the animal begins its burrowing



Plate 149. Cross section of the prismatic layer of *Pinna carnea* Gmelin showing the irregular prisms with conchiolin surrounding them (470x).

activities the anterior end of the shell, being downward, becomes eroded. Consequently, specimens with the embryonic valves still attached are extremely rare. As the shell grows, the body of the animal as well as both the anterior and posterior adductor muscles must move posteriorly (i.e., up). The anterior end of the shell is constantly worn away and the mantle deposits septa across the shell to protect the anterior adductor muscle (Plate 154, figs. 2, 4). Specimens are often found with a series of such septa in the narrow ends of the valves in front of the small anterior adductor muscle scar.

### SHELL STRUCTURE

The shell is very simple in structure and is composed generally of only two layers, the periostracum being extremely thin or entirely absent. The outer prismatic layer is calcitic and composed of very large crystals produced in a framework of conchiolin and set at right angles to the surface of the valves. These prismatic crystals, the largest produced anywhere in the Recent Mollusca, may be readily seen with the aid of a hand lens

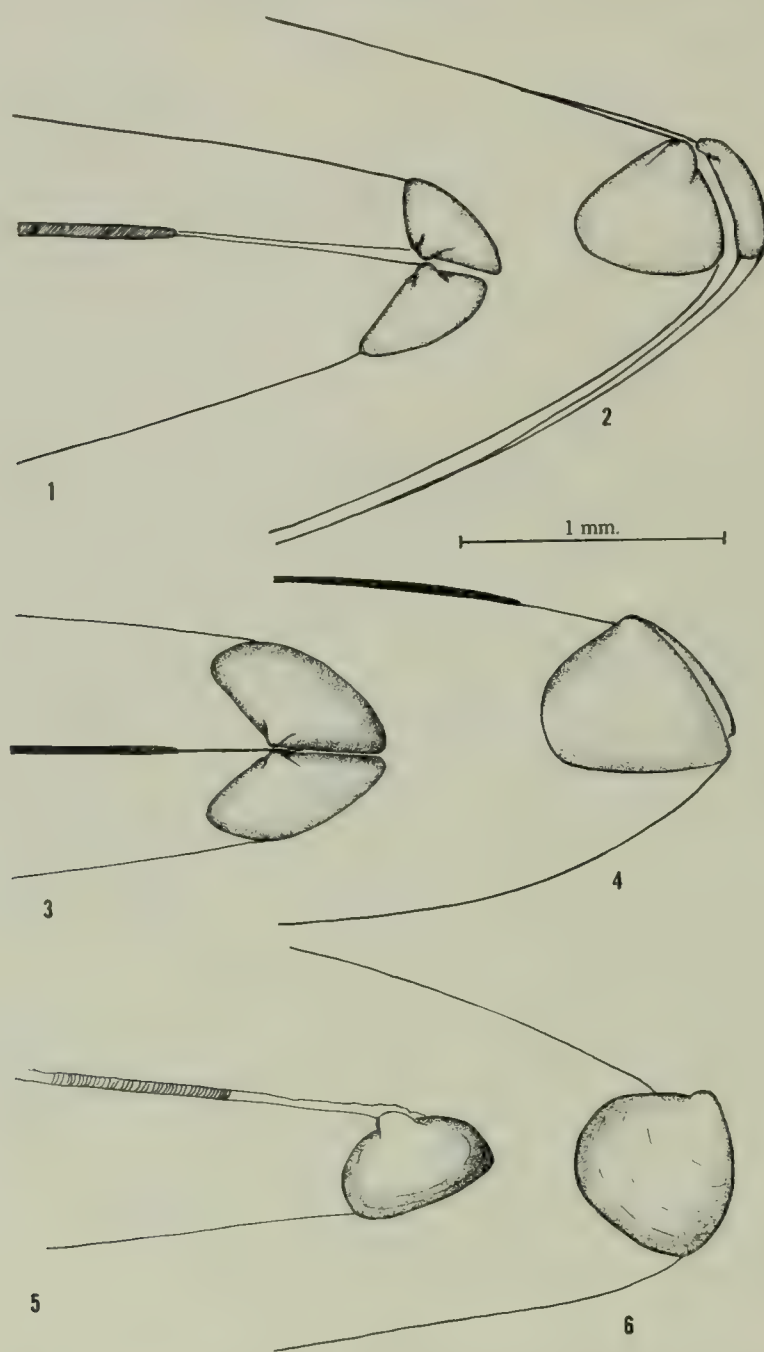


Plate 150. Embryonic valves of Pinnidae. Figs. 1-2. *Pinna carnea* Gmelin from reef northeast of North Point, Elbow Cay, Great Abaco, Bahama Islands. Figs. 3-4. *Pinna rudis* Linné from the Mediterranean. Figs. 5-6. *Atrina* (*Servatrina*) *seminuda* Lamarck from off Tobago, Lesser Antilles in 36 fathoms.

and in older specimens are often sufficiently large to be seen without magnification. Transverse and longitudinal sections of the prismatic layer of *Pinna carnea* are shown in Plate 149 and Plate 151, figs. 1-2. That portion of the shell posterior to the large posterior adductor muscle is composed only of this prismatic layer and, because of its high organic content, is slightly flexible in living specimens. The inner, nacreous, layer is produced only in the anterior portion of the valves and mainly in the area between the two adductor muscles (Plate 154, figs. 2, 4). It is composed of flat, shingled layers of aragonitic, nacreous material which parallel the long axis of the valves. The extent and shape of the nacreous layer are important characters in the classification of this family as is shown in the systematic portion of this paper. One of the earliest studies to be made on the structure of the shell was that of Carpenter (1844) in which he described the irregularly hexagonal crystals and the network of conchiolin which holds them together. Additional contributions were made by Biedermann (1901) and Karny (1913). A summary of this work as well as a brief discussion of the shell structure of Recent and fossil Pinnidae and related forms is given by Böggild (1930) in his interesting paper, "The Shell Structure of the Mollusks."

Hinge teeth are lacking and the valves are united along their dorsal margin by a ligament which is divided into two main portions which C. M. Yonge (1953) has termed the primary and secondary ligaments. The ligament proper (primary ligament) extends from the anterior adductor muscle posteriorly to the posterior margin of the inner nacreous layer. The fusion of the valves on the dorsal margin posterior to this is a result of the fusion of the mantle lobes and, though called the secondary ligament, is not a true ligament. The primary ligament in the Pinnidae is not elastic but it is, however, similar in structure to that found in other bivalves.

#### NOTES ON ANATOMY AND PHYSIOLOGY

The Pinnidae have a large, more or less centrally located posterior adductor muscle and a very small anterior adductor muscle. The soft parts are confined mainly to the area between the two muscles; only the greatly enlarged posterior lobes of the mantle and the elongate ctenidia or gills extend beyond the posterior adductor muscle. Both the mantle and the gills are capable of retraction to the muscle. There are no true siphons, but the mantle cavity is divided into incurrent and excurrent chambers by an intermantle septum. The anatomy of *Pinna nobilis* Linné has been described and figured by Poli (1795), that of *Atrina rigida* Solander by B. H. Grave (1911) and of *Pinna carnea* Gmelin by C. M. Yonge (1953). Since the general morphology of the soft parts of these species varies but little they will be discussed together, the differences being noted where necessary.

There are many unique characters in this family which fit it for its peculiar mode of life. Members of the Pinnidae generally live embedded vertically in a soft substratum attached to stones or other objects by a large byssus. Usually that portion of a shell not occupied by the soft parts (i.e., the portion posterior to the posterior adductor muscle) protrudes above the surface where it is exposed and is often broken. This protrusion of the shell above the soft substratum, however, allows the animal, which does not have extendible siphons, to get water from well above the bottom and so to avoid much of the debris which might otherwise be drawn into the mantle cavity. The Pinnidae burrow more deeply into the substratum as the shell grows, the anterior end being worn away while the growth of shell is almost entirely at the posterior margin. Though the mantle

adheres closely to the shell it is attached only at two points and so can be readily retracted. The greatly enlarged and retractable portion of the mantle is supplied with numerous pallial muscles which radiate from the two pallial retractor muscles as shown in Plate 152. The fact that the mantle can be retracted quickly on the slightest stimulus prevents injury to the mantle proper and thus allows rapid repair of the shell if it has been broken. When completely retracted the mantle and gills lie folded closely against the posterior adductor muscle and in this condition cover only the area corresponding to the inner nacreous layer of the shell.

A unique and very important structure in the Pinnidae is the waste canal by means of which particles of sand and other debris are carried from the incurrent portion of the mantle cavity. The waste canal consists of slightly raised channels, one on each lobe of the mantle, which oppose each other to form a tube. The inner surfaces of the channels are lined with strong cilia and are supplied with mucous glands. The canal extends nearly the length of the mantle and parallels the outer margin of the gills. All material entering the canal is carried rapidly posteriorly (upward) and is consolidated with mucus into strings and ejected. Although the waste canal is highly developed in the Pinnidae, it is analogous to the ciliary tracts which function in the ejection of particles from the incurrent siphon in other bivalves.

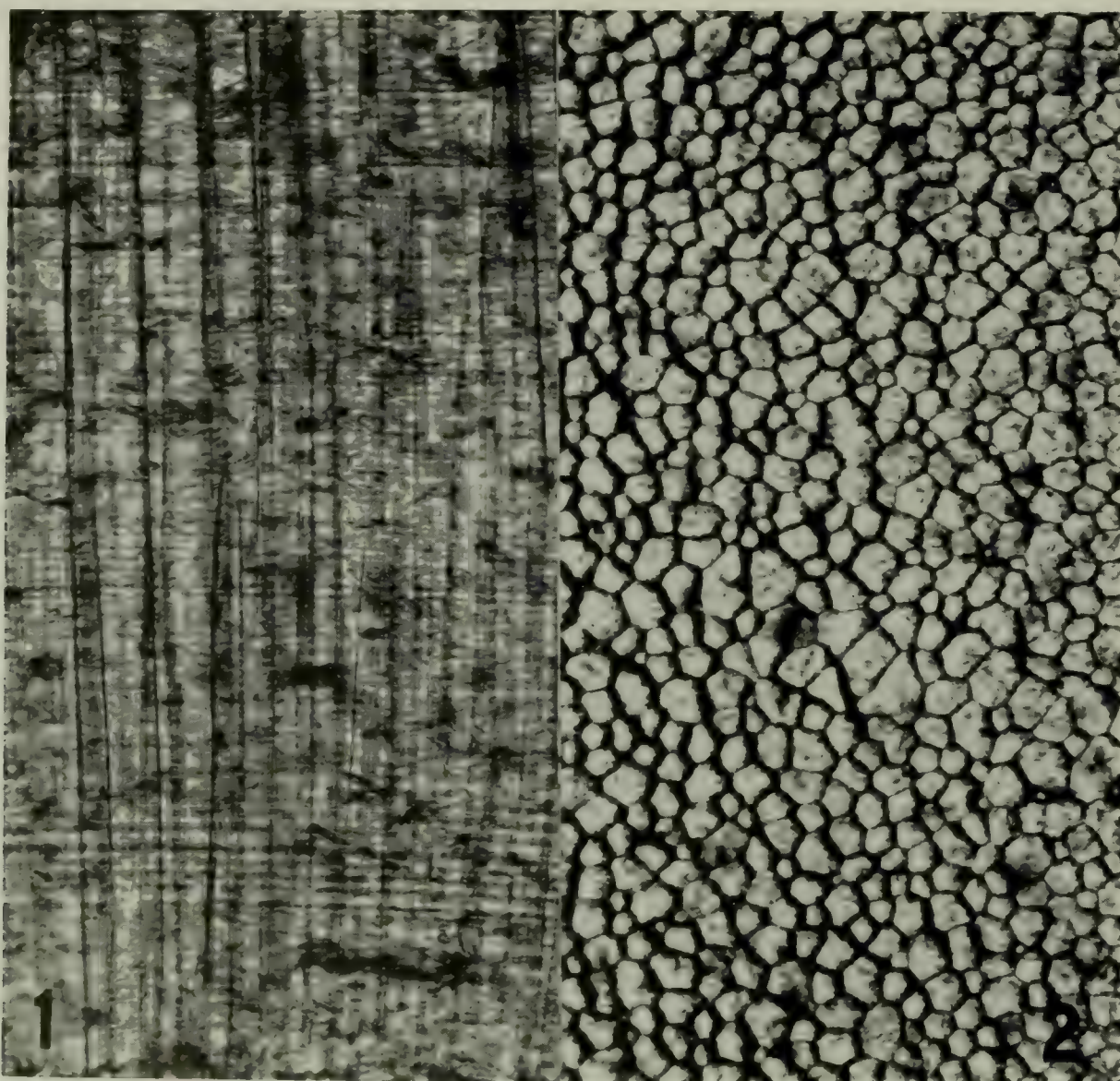


Plate 151. *Pinna carnea* Gmelin, shell structure. Fig. 1. Section to show the length of the crystals of the prismatic layer (i.e., thickness of the shell). Fig. 2. Section to show surface of the crystals in cross section from the same area of the shell as in Fig. 1. (Both 110x.)

The mantle is important in cleaning and in repairing the shell, but the Pinnidae possess in addition a unique structure, the pallial organ, which, according to C. M. Yonge, probably functions only when the shell has been broken. At such times, after the mantle has been retracted, the pallial organ may be distended so that it is large and turgid. It can then be protruded to the edge of the valves where it actively pushes out broken pieces of shell and debris. The pallial organ at such times is extremely active and many of its movements appear aimless, but there seems to be little doubt that its function is that of clearing away the larger particles which are too heavy for the cilia of the mantle to handle. The mantle gradually extends to the edge of the break and the repair and rebuilding of the shell begin. These shells are so fragile and so subject to breakage that one seldom finds a large specimen which does not show evidence of numerous breaks. Grave (1911) reported that a hole one half by three fourths of an inch was completely repaired in three days.

Our observations on living specimens would indicate that the pallial organ functions whenever the mantle is partially contracted, even if the shell is not broken. If one valve of *Pinna* or *Atrina* is carefully removed and the specimen kept in a pan of well-aerated

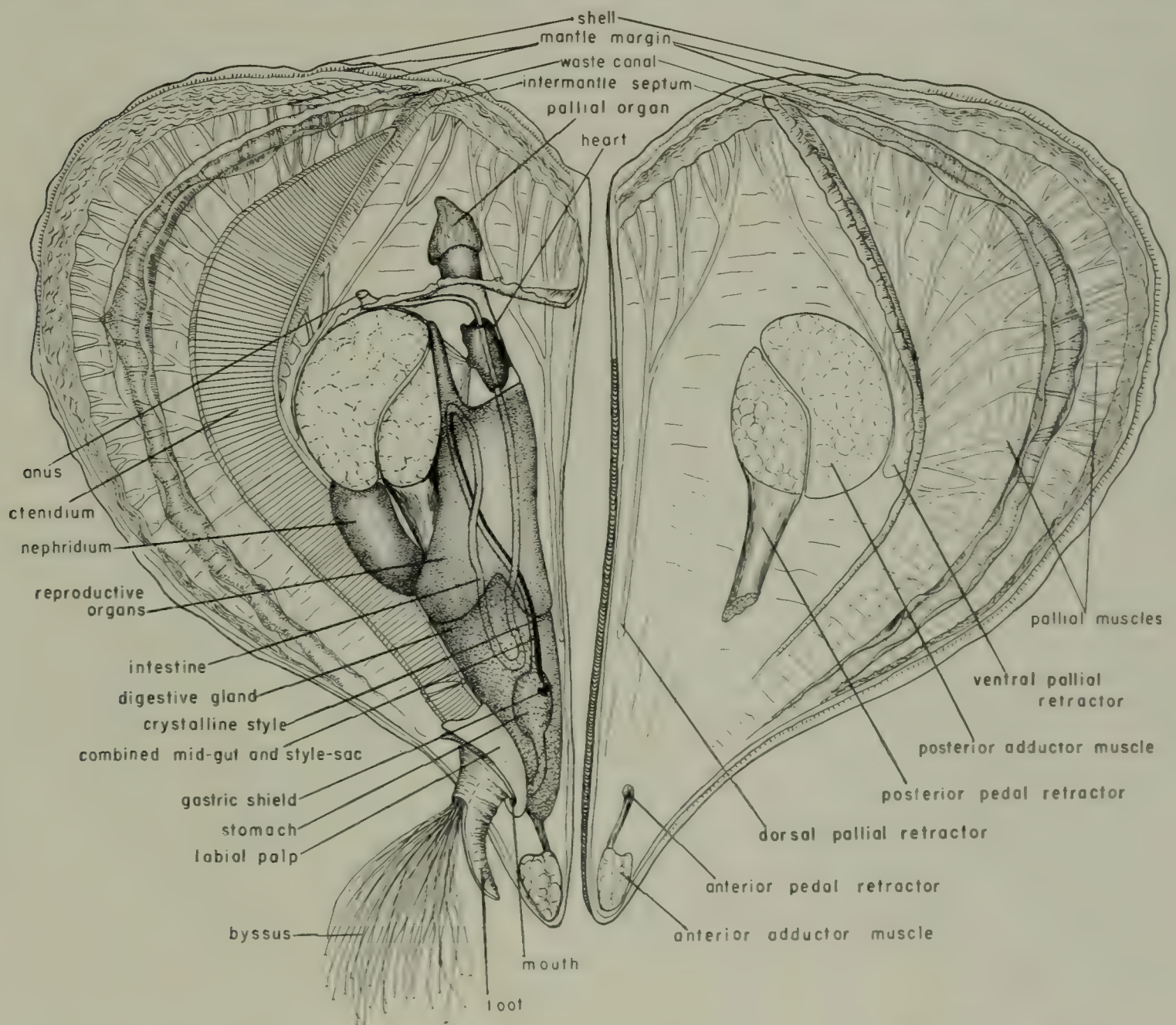


Plate 152. Semidiagrammatic drawing of the anatomy of *Atrina rigida* Solander. The right half shows only the muscles and the characteristic features of the mantle.

sea water, the live animal can be observed easily. With the mantle partially retracted due to the fact that one valve had been removed, the material carried posteriorly by the waste canal could not be carried beyond the valve and it collected at the posterior end of the canal. When a sizeable ball of this matter had collected, the pallial organ (in one of the three live specimens studied) extended and pushed it out of the shell. When not observing the animal we replaced the valve and in this way were able to keep it fairly active for three days.

On Plate 152 we present a semidiagrammatic drawing of the gross anatomy of *Atrina rigida* Solander. To make this sketch the adductor muscles were cut just inside the mantle on one side so that only the mantle and portion of the cut muscles were left adhering to the right valve. On the left valve we have shown the animal as it can be seen without dissection. We have, however, indicated (as if the animal was transparent) the esophagus, stomach, combined mid-gut and style sac, and the intestine which cannot be seen without dissection for these are embedded in the large digestive gland and reproductive organs. The crystalline style in *Atrina* is unusually large—a specimen 150 mm. long having a style 48 mm. long and 2 mm. in diameter at the anterior end.

Purchon (1957) described in detail the stomachs of *Atrina vexillum* Born and *Pinna atropurpurea* Sowerby, both species of the Indo-Pacific region. He mentioned in particular the development of a long slender tongue on the major typhlosole, a fold in the interior of the stomach. This tongue extends into the food-sorting caecum of the stomach, greatly increasing the efficiency of the latter. This development of the tongue on the typhlosole is shared with the Arcidae, Glycymeridae, Mytilidae, Vulsellidae [= Isognomonidae], Pteriidae and Ostreidae. Purchon considered that the evolution of such a tongue could neither have arisen independently in several lines nor did he believe that the tongue, once produced, could have been lost independently. Therefore he concluded that these families are monophyletic, but before definite relationships between these families can be established, studies of other organs and the shells must be made. Certainly the Mytilidae, Vulsellidae, Pteriidae and Pinnidae are close in their relationship and this similarity in stomach structure is one more factor relating them. Our observations on the stomach of *Atrina rigida* Solander agree closely with those of Purchon.

A discussion of pinnaglobin, the brown pigment in the body fluid of the Pinnidae, was given by Suto (1938). Suto did not believe that it had much oxygen-holding capacity and he suggested that further work is needed on this problem.

In a recent paper on the physiology of *Pinna* muscle, Abbott and Lowy (1956) have shown that, in this group, the posterior adductor muscles behave similarly to those of other bivalves. They show that there is a fast and slow acting portion to the muscle and that the economy of these muscles is due to their slow rate of relaxation following contraction. On this basis it is interesting to note that, though the Pinnidae do not have an elastic ligament against which the muscles must work to keep the shells closed, the valves themselves, due to their high organic content are flexible and probably take over the function of the ligament in opening the valves.

#### ECONOMIC IMPORTANCE

The Pinnidae cannot be classed rightfully among the important economic mollusks though probably no other family of mollusks yields so many products. The large adductor muscles of both *Pinna* and *Atrina* are eaten in many countries where species of these

genera occur. However, European writers state that they require much cooking and are rather tough, though of excellent flavor.

In Japan, according to A. R. Cahn (1951), there is an active and important fishing industry for *Atrina japonica* Reeve. The posterior adductor muscles are marketed fresh and the clam meats, exclusive of the muscles, are sold either raw or as dried meats which have first been boiled. They are highly esteemed as food. Even the discarded shells are used as a cultch for seed oysters and, when ground, they are used as fertilizer. No part of the animal is wasted in these Japanese fisheries. When *Atrina* occur intertidally they are harvested on the night low tide by torchlight, using a stick with a hook to extricate the shell. In areas where the species occurs in deeper water, fishing is done by divers operating from a boat. They use a regulation diving suit with air hose and work for periods as long as six hours in depths of twenty meters. The clams are usually pulled out with a barbed spear which penetrates the valves of the shell. So important is this fishery in Japan that there are government regulations concerning the season for harvesting and the quantity that can be taken.

On the west coast of Mexico in the vicinity of Mazatlan, *Atrina maura* Sowerby and *Pinna rugosa* Sowerby are important items of food among the natives. Pilsbry and Lowe (1932) described the heaps of empty shells found there and stated that the large muscle tastes like that of giant scallops. Mexicans call the shells "hachas" or hatchets and they are fished in much the same manner as that described for the Japanese fisheries. Mr. John Fitch of the California Fisheries Laboratory has written us recently that there is an active fishery for *Atrina maura* at San Blas, Nayarit, Mexico.



Plate 153. The byssus of the Pinnidae. Fig. 1. Byssus of *Atrina rigida* Solander from Bunch Beach, Florida to show the long fine threads which may be used in weaving (about  $\frac{2}{3}$  natural size). Fig. 2. *Pinna nobilis* Linné, from Cannes, France, the large Mediterranean species which produces a byssus used in the manufacture of garments (about  $\frac{1}{4}$  natural size). Fig. 3. A glove knitted from byssus fibers at Tarento, Italy (USNM no. 149395; about  $\frac{3}{8}$  natural size).

No one seems to have used the Pinnidae of the Western Atlantic for food though Mr. Harvey Bullis of the U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Pascagoula, Mississippi says they are excellent either raw or cooked.

All species in this family produce nacreous pearls, and though they are often irregular in shape, perfect specimens are quite valuable. Pliny mentioned the practice of diving in the Mediterranean for *Pinna* in order to obtain the pearls, and Poli (1795) reported taking twenty pearls from a single specimen of *Pinna nobilis* Linné. However, it was apparently in India where the fishing of Pinnidae for pearls was an important industry among the ancients. In the records of Alexander's Indian Expedition it was mentioned that in Indian seas these shells were obtained by diving for the sake of the pearls. Grave (1923) stated that he found pearls in about one fifth of all the specimens of *Atrina rigida* he examined for his studies. According to his account the pearls were black, usually spherical and quite smooth. He said they had been used in the manufacture of brooches and other articles of jewelry and he could see no reason why they should not be used more extensively. In an interesting paper on the "Natural History of the Pearls" Hass (1955) described the structure of pearls in the Pinnidae. These pearls have radially arranged prisms, a condition quite unlike that of all other pearls. This is a result of the unusual structure of the shell as discussed previously. Because of the radially arranged prisms and the large amount of organic material between the prisms, the pearls usually fragment on drying out and so are rather short-lived. As a result they are considered of relatively little value at the present time. However, pearls produced in the anterior portion of the mantle which lays down laminated, nacreous material would be composed of concentric layers rather than radial prisms. Such pearls should be durable and valuable.

The most famous product produced by the Pinnidae is the byssus fiber, which is an extremely fine and soft but strong fiber produced by a gland in the foot of the animal for the purpose of anchoring the shell. The byssus fiber of some of the larger species in this family is sufficiently long so that it can be spun and then woven or knitted to make small garments. It has a beautiful golden bronze sheen and was often combined with silk when used in making larger garments. Most authorities believe that the use of the byssus

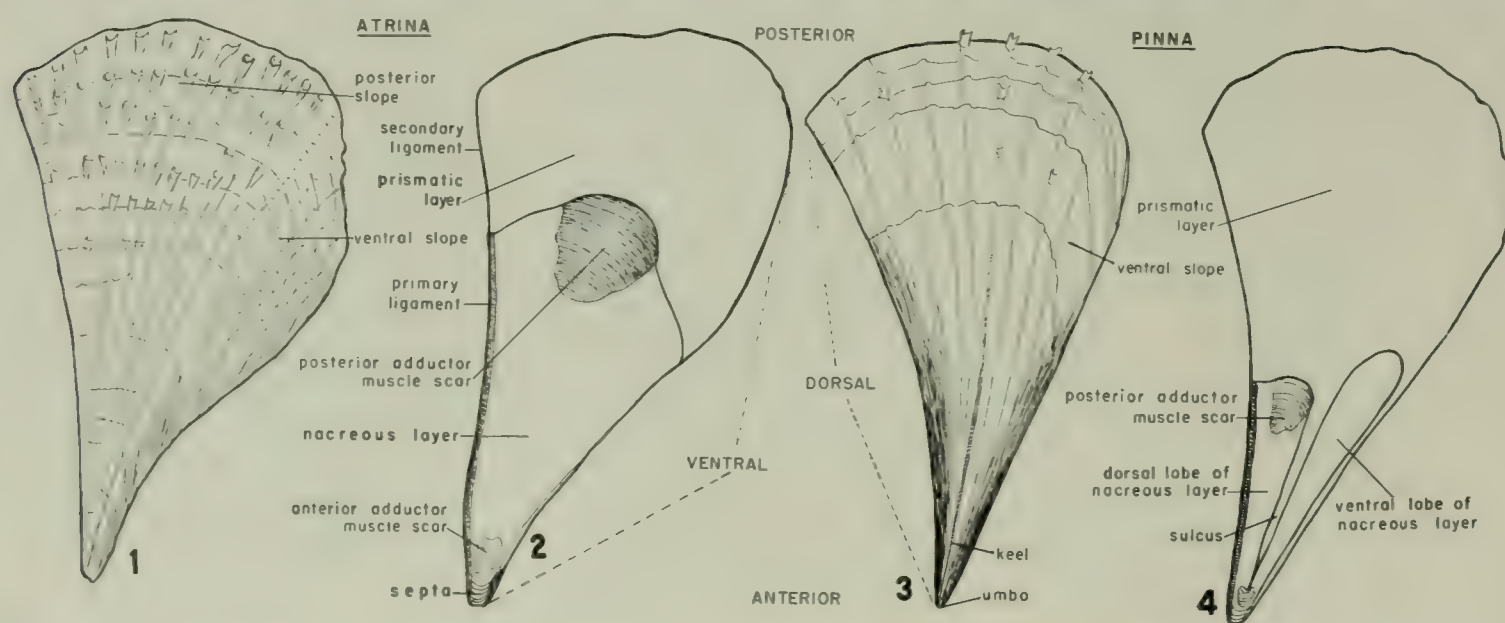


Plate 154. Diagrammatic sketch of the valves of *Pinna* and *Atrina* to show diagnostic characters. Fig. 1. External surface of valve of *Atrina*. Fig. 2. Internal surface of valve of *Atrina*. Fig. 3. External surface of valve of *Pinna*. Fig. 4. Internal surface of valve of *Pinna*.



Plate 155. *Pinna rudis* Linné from Pointe Noire, Gaboon, French Equatorial Africa. Fig. 1. Internal surface of valve showing the difference in length of the two lobes of the nacreous layer in a large adult specimen (about  $\frac{1}{3}$  natural size). Fig. 2. External surface of the valve showing the large spines of a typical specimen (about  $\frac{1}{2}$  natural size).

as a fiber in making garments probably originated in India near Colchi. This is based on the fact that the earlier Greek and Roman writers referred to *Pinna* but did not mention the use of the byssus before the time of Tertullian (150–222 A.D.). Tarento was the center of the industry in Italy, and Procopius, who wrote on the Persian Wars about 550 A.D., stated that the five hereditary satraps (governors) of Armenia who received their insignia from the Roman Emperor were given chlamys (or cloaks) made from *lana pinna* (*Pinna* “wool,” or byssus). Apparently only the ruling classes were allowed to wear these chlamys. Even today a small remnant of the former industry remains in Italy and a few articles such as gloves, hats, shawls and stockings are made mainly for the tourist trade. According to Simmonds (1879) in “The Commercial Products of the Sea,” the byssus formed an important article of commerce among the Sicilians, for which purpose considerable numbers of *Pinna* were annually fished in the Mediterranean from a depth of 20 to 30 feet. He also said, “a considerable manufactory is established at Palermo; the fabrics made are extremely elegant and vie in appearance with the finest silk. The best products of this material are, however, said to be made in the Orphan Hospital of St. Philomel at Lucca.” Though the modern gloves and shawls are knitted, the chlamys, gloves and stockings of the ancients were woven, for knitting was not known until about 1500 according to Yates (1843). Articles made from *Pinna* byssus are extremely strong and durable except that they are readily attacked by moths so that great care must be taken in their preservation. There are, as a consequence, very few examples of the early garments in existence. On Plate 153 are shown the cleaned byssus of *Atrina rigida* Solander; the shell of *Pinna nobilis* Linné, the species from which the byssus was obtained for the Italian industry; and a glove made from byssus fiber at Tarento, Italy.

The etymology of the word “byssus” was discussed by van der Feen (1949, pp. 66–71). It was shown that the word was derived from two very similarly sounding Greek terms, one denoting depth (of the sea or a river), the other referring to fine vegetable fibers which were woven into valuable fabrics by the ancients. In 1476 Gaza, through an error in translation of a section concerning *Pinna* in Aristotle’s “Historia Animalium,” originated the use of the word byssus as it is applied to the holdfast fibers of the Pinnidae, Mytilidae, Pteriidae, etc. He did this by confusing the Greek word for depth, as used by Aristotle in describing the ecology of *Pinna*, with the term for the vegetable fibers and may have genuinely believed that Aristotle intended the word to be applied to the holdfast. In 1555, Rondelet perpetuated and popularized this mistake and in this way the term became established. Gesner in 1558 was the first to oppose the erroneous use of byssus and criticized Gaza’s work. Since that time various workers have taken a stand against the use of the word and a few have championed it including Sir d’Arcy Thompson in 1910. Although the word byssus is used universally today in referring to the holdfasts of bivalve mollusks it is interesting to reflect upon the uncertain basis for its use and history of origin.

Because the Pinnidae are such unique bivalves and have intrigued man since early historic times there are a host of common names for this group. In France they are known as ‘jambons’ or ham-shells, because of their shape, and the Mexicans refer to them as ‘hachas’ or hatchets. In England they are known as fan-mussels, fin-shells or sea-wings and in the United States they are often referred to as pen-shells or sea-pens. The Australians refer to them as razor backs or razor clams as it is so easy to cut one’s feet on them. This common name should not be confused with that of *Ensis* or *Siliqua* which are also called razor clams because of their shape.

## ASSOCIATES OF THE PINNIDAE

The Pinnidae are host to a number of organisms which live both upon the outside of the valves and in the mantle cavity. Most of the associated organisms use the shell only as a point of attachment and support. Perry (1936) reported finding a total of twenty-five different organisms living in association with *Atrina rigida*. From a fine shipment of this species which we received from Harvey Bullis, dredged from 3-4 fathoms off Tampa Bay, Florida, we removed 28 species of mollusks of which 12 were living, as well as barnacles, tube worms, hydroids, algae, bryozoa, tunicates and brittle stars.

Some of the organisms associated with the Pinnidae, particularly crustaceans, have an interesting commensal relationship with them. Aristotle was the earliest writer to mention the interesting association of a crab with *Pinna*. Chemnitz (1785) fully described this small crab, *Pinnotheres*,<sup>1</sup> which lives in the mantle cavity of *Pinna*. The crab was said to leave the cavity periodically, but always to return when danger threatened, thus warning the *Pinna* which would thereupon close its valves protecting both itself and the *Pinnotheres* within. This fanciful story of the "friendship" of these two animals was made famous by Pliny and additional accounts of this relationship have been written by Poli (1795), Montagu (1803), Johnston (1850), Jeffreys (1863) and others. Apparently,



Plate 156. Holotype specimen of *Pinna varicosa* Lamarck [= *P. rudis* Linné] from Trinidad, Lesser Antilles.

Fig. 1. Outer surface of valve. Fig. 2. Inner surface. Fig. 3. Sketch of the inner surface of the valve to show arrangement of nacreous layer and the muscle scar. The photographs and drawing by courtesy of Dr. J. Gaillard and the Muséum d'Histoire Naturelle, Paris (all about  $\frac{1}{2}$  natural size). This specimen is typical of the stunted form of *rudis* as it occurs in the West Indies.

<sup>1</sup> *Pinnotheres*, from the Greek: *Pinna* + *terein*, to guard, i.e., the *Pinna* guardian.

wherever members of the Pinnidae occur there are some small crabs which live with them. In fact, W. L. Schmitt (1931) stated that "edible mollusks in all parts of the world are infested by commensal crabs." Dr. Schmitt also stated that shrimp have adopted this way of life, that one rarely finds more than one adult shrimp or crab in a shell and this is usually a female. The adult males visit from shell to shell, but the females seldom if ever voluntarily leave the mantle cavity of their hosts. These crustaceans live in their sheltered homes sharing the food which is brought into the mantle cavity of the mollusk during its normal feeding process. They are of no benefit to the bivalve as was supposed by early writers and according to Christensen and McDermott (1958) they probably cause some damage to the gills. This is certainly true of *Pinnotheres ostreum* Say which is associated with *Crassostrea virginica* Linné. These authors made a complete study of *P. ostreum* and gave a summary and bibliography of work done on the life history of *Pinnotheres*. We have seen specimens of *P. maculatus* Say taken from *Atrina rigida* which



Plate 157. *Pinna carnea* Gmelin from Port Royal, Cat Island, Bahama Islands. Fig. 1. Outer surface of valve showing the pronounced keel at the anterior end and the few small spines. Fig. 2. Inner surface of valve showing the arrangement of the nacreous layer (both about  $\frac{1}{2}$  natural size).

were collected at Sanibel Island, Florida. A shrimp was observed living in the mantle cavity of a large *Pinna carnea* at Bimini, Bahama Islands, by Robert Robertson of the Museum of Comparative Zoölogy. The shrimp sat on top of the posterior adductor muscle of the *Pinna* in an exposed position, but when disturbed it moved backwards and down around the muscle until hidden from view.

#### NOTES ON THE FOSSIL RECORD

The fossil record shows that the Pinnidae were reasonably well represented in geologic time. Although many fossils have been reported, very few whole valves have been figured. This is probably due to the fact that these fragile shells are not readily preserved as fossils. Usually only fragments representing the prismatic layer remain and there is seldom any indication of the extent or shape of the nacreous layer. As this portion of the shell is very important in the classification of the family, few conclusions can be drawn from the fossil record concerning the evolution of this group. Hyatt (1892) discussed the fossil Pinnidae and their relationship to recent forms. He suggested that when material was available it would probably be found that in the early stages the nacreous layers of *Atrina* and *Pinna* would be quite similar in outline with the carina and division of the nacreous layer of *Pinna* appearing at a later stage. Our observations on very young specimens has shown this to be true as well as the fact that on the embryonic valves the umbos are not terminal though in the adult stage they virtually come to take this position.

Hyatt, and later Zittel, recorded the family as having existed since the Devonian. *Atrina* Gray which is known from the Carboniferous is apparently the oldest of the Recent genera in the Pinnidae, for the earliest known record of *Pinna* Linné was from the Jurassic. Another factor which suggests that *Atrina* is the oldest genus is the internal structure of the shells. The nacreous layer of *Atrina* is undivided, with the muscle scar more or less medial, while that of *Pinna* is divided by a longitudinal sulcus and has the muscle scar displaced toward the dorsal margin. These differences may be indicative of a change from simple to more complex shell structure. It has been pointed out (cf. Beecher 1898) that in mollusks the development of more complex shell structure is a sign of aging in a group. Of course, the situation is always complicated by the possibility of a secondary redevelopment of more simple characters, but this does not seem to have occurred in the Pinnidae.

Paleontologists have assigned several extinct genera to the family Pinnidae. One of these, *Palaeopinna* Hall 1870 from the Devonian, is the earliest record for the family. The shell of *Palaeopinna* (cf. Shimer and Shrock 1944, p. 387, pl. 150, fig. 12) lacks the external keel of *Pinna*, has convex umbos, and very fine radiating ribs. *Aviculopinna* Meek from the Carboniferous and Permian differs from Recent Pinnidae in that the umbos are located subterminally so that a small wing is present in front of them. A third fossil genus, *Pinnogena* 'Saussure' Bronn 1836, was reported from Jurassic and Cretaceous rocks. It somewhat resembles an oyster. The figure of *Pinnogena seebachi* Böhm, in Zittel (p. 368, fig. 621) shows a nearly entire shell with an enormous elongate, centrally located muscle scar. On the exterior of the valves there are large, convex ribs which radiate out from a central groove. The genus *Sulcatopinna* was proposed by Hyatt for Carboniferous forms having extremely elongate shells with a straight hinge line, approximately terminal umbos and with the valves ridged on the dorsal area. He suggested that this group may have been the forerunner of *Pinna*.

The general form of a very early member of the Pinnidae gained from a survey of representative genera is something resembling both *Pteria* and *Pinna*. This is most evident when the fossil genus *Aviculopinna* is considered. *Palaeopinna* bears a general resemblance to both the Pteriidae and the Mytilidae, families generally placed near the Pinnidae by neontologists.

There is reason to believe, from the fossil findings, that the family Pinnidae was quite differently distributed in the past than it is today. Present data show that there are no species found on the west coast of North America north of Mexico, except *Atrina oldroydi* Dall which has been taken in 25 fathoms in San Pedro Bay in southern California. However, Crickmay (1930, p. 47) reported having found a *Pinna* in Jurassic strata of British Columbia, and Vokes (1939, p. 50) described an Eocene *Pinna* from San Joaquin Valley, California. Ivanov (1926, p. 175) listed *Pinna* (*Aviculopinna*) *membranacea* Kon. from the Carboniferous of Moscou [Moscow]. Grant and Gale (1931, pp. 145-147) reported two species of *Pinna* from the Pliocene and a species of *Atrina* from the Miocene of California.

From the foregoing discussions it seems reasonable to conclude (on the basis of shell structure, anatomy and the fossil record) that the Mytilidae, Isognomonidae, Pteriidae, Pinnidae and probably the Ostreidae, evolved from some common ancestor.

#### NOTES ON CLASSIFICATION

Though the family Pinnidae is characteristic and easily recognized, classification below the family level is difficult and the opinions of the various authors who have worked with this family vary considerably. Iredale (1939) recognized seven genera in contrast to the single genus with three subgenera recognized by Winckworth (1929) and the single genus with only two subgenera by Thiele (1934). There appear to be, however, three well marked and easily recognized genera (the subgenera of Winckworth), *Pinna* Linné, *Atrina* Gray and *Streptopinna* von Martens. This generic classification was used by Habe (1953) in his paper on the Pinnidae of Japan. He recognized three subgenera of *Pinna* and two subgenera of *Atrina*. Only *Pinna* s.s. and two subgenera of *Atrina* are represented in the Western Atlantic.

On the specific level there is even less agreement among authors. Winckworth in his catalogue listed 175 names as having been introduced into the literature concerning this family. Of these he regarded only 29 as being valid species. Iredale commenting on this great reduction of names said, "this seems obviously a *reductio ad absurdum*, and is probably as far from the facts as the total number of names is." It should be taken into consideration, however, that Winckworth included in his catalogue not only all validly introduced names but also errors in spelling, nomina nuda and names from pre-Linnean authors and non-binomial works. There are 37 such entries in his catalogue which gives a ratio of about one in five remaining as a valid species. Just how many species will be recognized when the Pinnidae of the world have been adequately studied is hard to say but the number probably will be slightly higher than that of Winckworth, perhaps 45 to 50.

Linné (1758) instituted the genus *Pinna* and described eight species, three of which are unrecognizable and a fourth referred to the pen of a *Loligo*. These have been treated by Hanley, Winckworth and Dodge. Lamarck also described eight species, the type

specimens of which have been discussed by Lamy. The two outstanding illustrated monographs are those of Chemnitz in the "Conchylien Cabinet" and Reeve in the "Conchologia Iconica." The latter is particularly important as the type specimens of Reeve and Sowerby (some 39 species) were all figured in this study. Hedley (1924) reviewed the Australian Pinnidae, recognizing 19 species and two subspecies for that area and Winckworth covered the species of India and Ceylon. There has been no world-wide treatment of this group since that of Reeve except the catalogue by Winckworth.

The confused state of the taxonomy of this family and the differences of opinion of the various authors are probably the result of a number of difficulties inherent in the study of this group. Shells of the Pinnidae are extremely fragile and have a tendency to fracture spontaneously on drying out. This fragility, combined with the large size and generally unattractive appearance of these shells have made collectors reluctant to gather and ship them. Consequently museum collections are small, they lack comparative material of a geographic nature and seldom contain lots of more than 4 or 5 specimens from a given

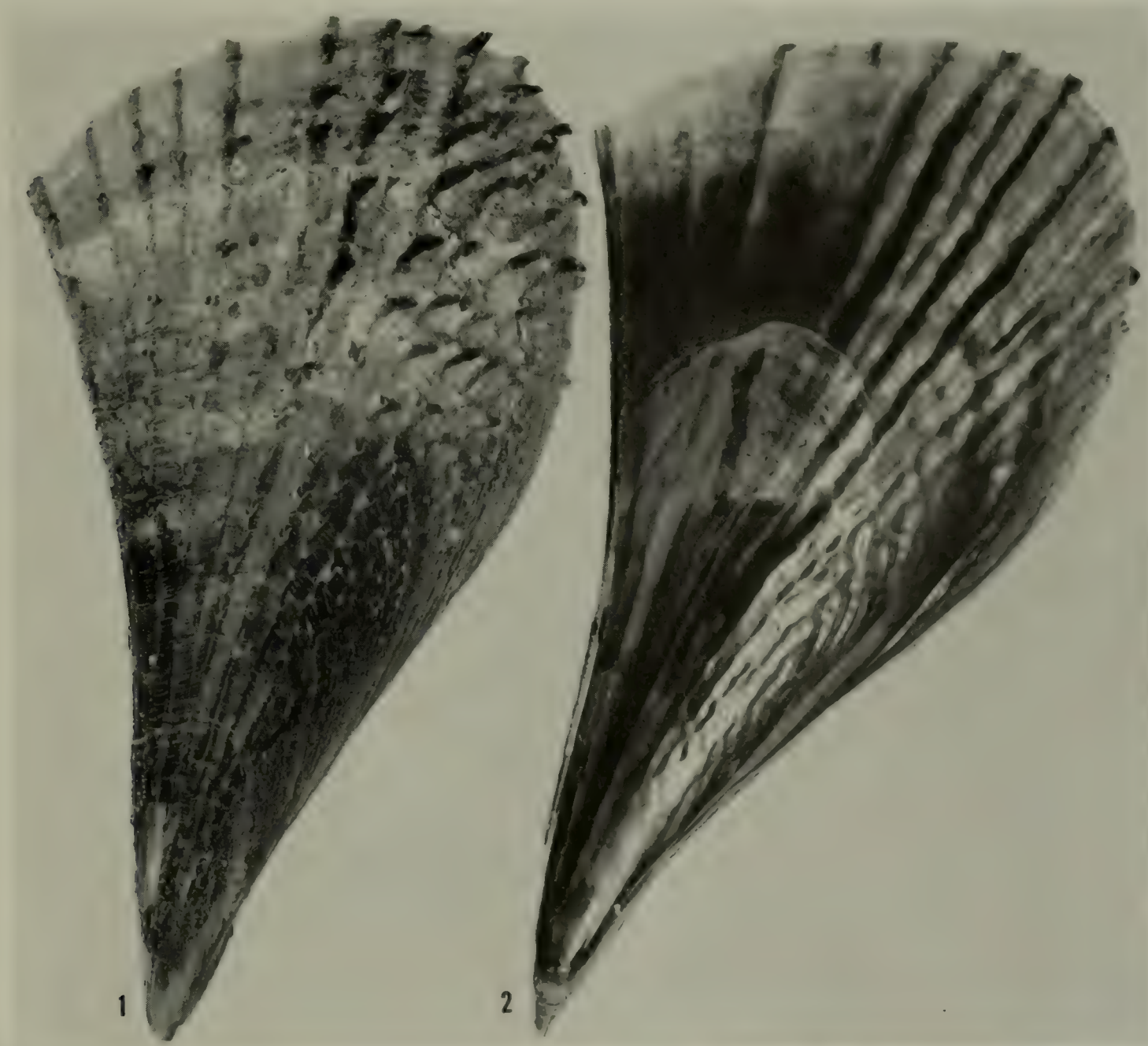


Plate 158. *Atrina (Atrina) rigida* Solander from Coconut Grove, Florida. Fig. 1. External surface of valve showing the tubular spines and the sculptured ventral slope. Fig. 2. Internal surface of the valve showing the nacreous layer and the protruding muscle scar (both about 3/5 natural size).

locality. Growth series are almost completely lacking. The Pinnidae as a whole have a capacity for ecologically induced variation and this has resulted in specimens of species which are widely separated geographically, such as *Atrina inflata* Dillwyn of Australia and *Atrina serrata* Sowerby of the Western Atlantic, having almost identical external appearances. However, when series are examined, the two species are found to be quite distinct. A similar problem may also arise with two species from the same locality, but actually belonging to different subgenera such as *Atrina* (*Atrina*) *rigida* Dillwyn and *A.* (*Servatrina*) *seminuda* Lamarek. These factors combined with the lack of large series in museum collections has resulted in many misidentifications as well as the naming of numerous forms which were apparently only ecologic variants. If the characteristics of the inner surface of the valves (the shape and extent of the nacreous layer and the muscle scars) are considered in conjunction with the external characters, most species can be determined readily. Unfortunately, however, few of the early descriptions either mentioned or illustrated the interior of the valves. Consequently, when using works such as Reeve's "Conchologia Iconica," it is often difficult, if not impossible, to place a species in the proper genus. Winckworth, Hedley and others have mentioned the importance of the muscle scars and the pattern of the nacreous layer in the classification of this family and our work has shown that these are among the best taxonomic characters.

Very little is known of the anatomy of most species of the Pinnidae and almost nothing is known of their breeding habits and life history. Further study on these problems will undoubtedly contribute to an understanding of the classification of the family and its relationships. Our observations on living animals show that the colors of the various organs, the position and curvature of the waste canal, as well as the size and shape of the pallial organ, are all excellent taxonomic characters.

We have included in the synonymies of the various species considered in the systematic portion of this paper only those names which we were certain referred to the species in question. Undoubtedly there have been some omissions, particularly in the synonymy of *Pinna rudis* Linné, an Eastern Atlantic species which occurs only sporadically in the West Indies. When reviewing the literature, one finds names such as *muricata* Linné applied to species belonging to both *Pinna* and *Atrina*, and coming from nearly all parts of the known range of the family. This is also the case with a number of other names though to a lesser degree.

#### ACKNOWLEDGMENTS

Many individuals and institutions have contributed valuable material used in this study as is shown in the records and we wish to acknowledge all of them. We are grateful to G. Usticke, St. Croix, Virgin Islands; Germaine Warmke of the Institute of Marine Biology, University of Puerto Rico, Mayagüez; Harvey Bullis of the United States Fisheries Laboratory, Pascagoula, Mississippi; and David and Nevada Schmidt of Sarona, Wisconsin for the material they collected especially for this study. Particular thanks are due Jean Foshee and Kathleen Johnstone of Mobile, Alabama and Robert Work of the Marine Laboratory, University of Miami who have sent both living and preserved material. H. A. Rehder of the United States National Museum and R. T. Abbott of the Academy of Natural Sciences, Philadelphia were helpful during our visits to these institutions to examine the collections. The collections of the California Academy of Sciences (CAS) and the San Diego Museum of Natural History (SDM) were also examined and

we wish to thank L. G. Hertlein and E. P. Chace for their cooperation. For the photographing of type specimens we are grateful to I. C. J. Galbraith of the Mollusca Section, British Museum (Natural History) and J. Gaillard of the Muséum d'Histoire Naturelle, Paris. Credit for these photographs is given in the plate captions. To W. J. Clench, M. E. Champion and our associates in the Mollusk Department, we are grateful for the discussion of several problems and for the reading of the manuscript; R. Robertson in addition aided in making the sections of the *Pinna* shell (Plates 149 and 150). We are indebted to Professor John H. Welsh, Biological Laboratories, Harvard University, for discussing with us certain physiological problems.

### WESTERN ATLANTIC PINNIDAE

The species of Pinnidae in the Western Atlantic may be identified by means of the following key which is based on adult specimens (see Plate 154).

1. Nacreous layer divided by a sulcus . . . . . 2 (*Pinna*)  
    Nacreous layer not divided by a sulcus . . . . . 3 (*Atrina*)
2. Ventral lobe of nacreous layer longer than dorsal lobe; valves usually pale red-orange, thin, with few if any spines; ribs 8-12 . . . . . *Pinna carnea*  
    Dorsal lobe of nacreous layer longer than ventral lobe; valves usually dark red-brown, thick, with large spines; ribs 5-7 (in the Western Atlantic usually stunted, deformed and devoid of spines, but in Eastern Atlantic large and spinose) . . . . . *Pinna rudis*
3. Posterior adductor muscle scar enclosed within nacreous layer . . . . . 4  
    Posterior adductor muscle scar protruding beyond posterior border of nacreous layer . . . . . *Atrina rigida*
4. Valves with numerous, crowded, fine ribs armed only with imbrications; ribs over 30; shell light greenish tan . . . . . *Atrina serrata*  
    Valves usually with few ribs armed with spines; ribs less than 20; shell grayish tan to black . . . . . *Atrina seminuda*

### Genus *Pinna* Linné

*Pinna* Linné 1758, Systema Naturae, ed. 10, p. 707 (type species, *Pinna rudis* Linné, by subsequent selection, Children 1823, Gray 1847).

*Chimaera* Poli 1791, Testacea Utriusque Siciliae 1, p. 31 (type species, *Pinna nobilis* Linné, by subsequent selection, Winckworth 1929).

*Chimaeroderma* Poli 1795, Testacea Utriusque Siciliae 2, p. 259 (type species, *Pinna nobilis* Linné, here selected).

*Pinnarius* Duméril 1806, Zoologie Analytique, p. 169, 340; Iredale 1939, Great Barrier Reef Expedition, Scientific Reports 5, no. 6, p. 309 [new name for *Pinna* Linné].

*Pinnula* Rafinesque 1815, Analyse de la Nature, ou Tableau de l'Univers et des Corps Organisés, Palerme, p. 147 (a substitute name for *Pinna* Linné).

*Cyrtopinna* Mörch 1853, Catalogus Conchyliorum Comes de Yoldi, part 2, p. 51 (type species, *P. incurva* Gmelin, by monotypy).

Type species, *Pinna rudis* Linné, by subsequent selection, Children 1823, Gray 1847.

Shell medium to large, reaching about 700 mm. (about 26 inches) in length, wedge-shaped, generally thin in structure and often sculptured with spinose or imbricate radiating ribs. Nacreous layer divided by a longitudinal sulcus into a dorsal and a ventral lobe, the

large posterior adductor muscle scar being on the dorsal lobe of the nacreous layer adjacent to the ligament.

This genus is found in nearly all tropical and subtropical seas with a few species reaching into temperate waters. Specimens are usually found living in sandy-muddy bottoms where they are firmly attached by large byssi, though in some areas they may be found living in crevices on rocky shores. A discussion of the biology of the group is given in the introduction.

There has been a great deal of controversy concerning the type species of this genus. Since Children's work (1823) it has been considered as *Pinna rudis* Linné. However, as Iredale (1939) has pointed out, Children selected types only for Lamarckian genera and so, even though Linné's and Lamarck's interpretations of *Pinna* were the same, the first selection of a type species of *Pinna* Linné was that of Gray in 1847. He selected as type *Pinna rudis* Linné and this selection has been recognized since that time. Unfortunately, Grant and Gale (1931), attempting an absurdly strict interpretation of the Rules of Zoological Nomenclature, stated that according to Article 30d and Opinion 16 the type would have to be *Pinna muricata* Linné. They based their argument on the fact that

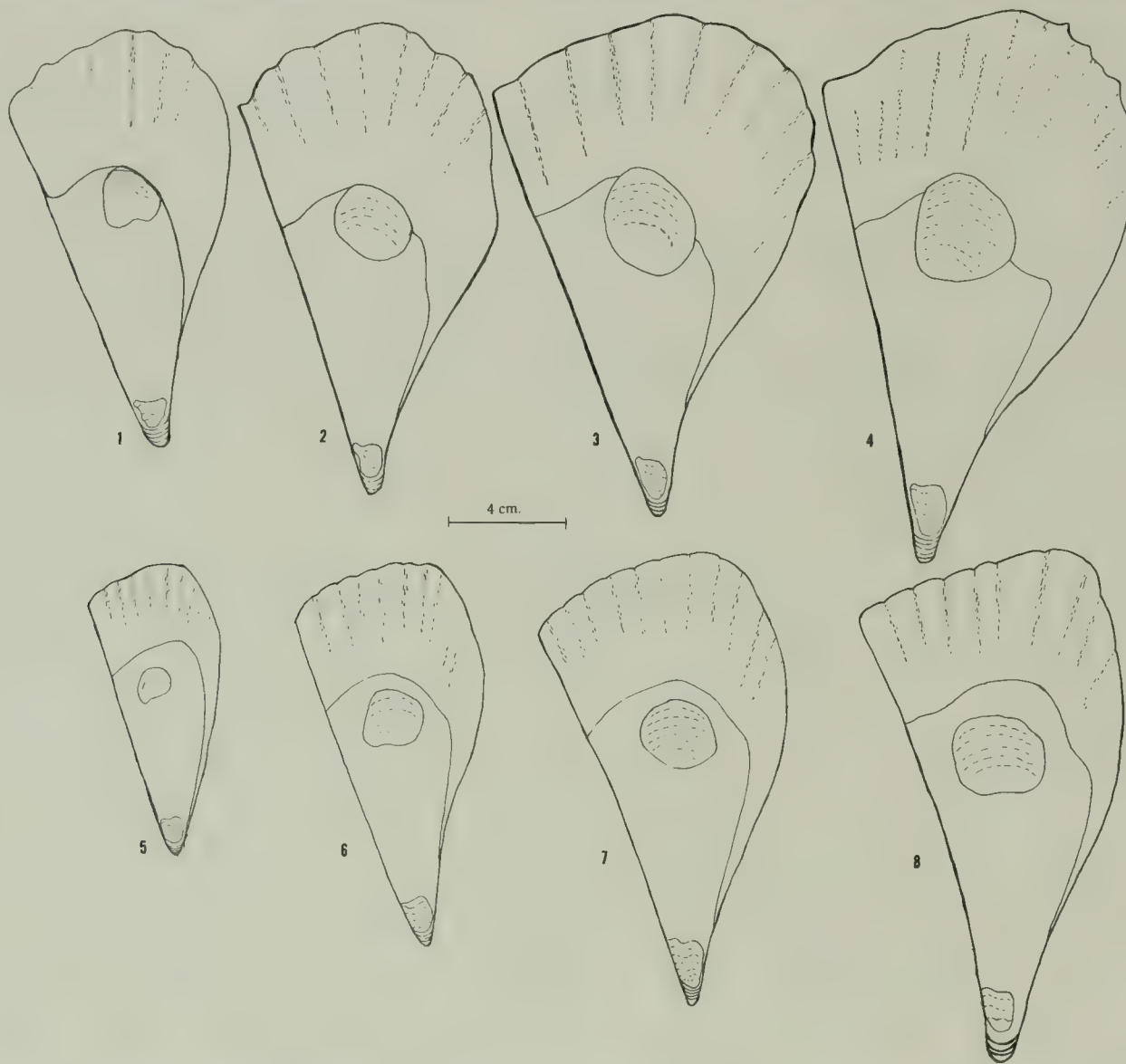


Plate 159. Variations with age in *Atrina* (*Atrina*) *rigida* Solander and *Atrina* (*Servatrina*) *seminuda* Lamarck.

Figs. 1-4. *Atrina rigida* Solander from off Tampa Bay, Florida in 3-4 fathoms. A series from one locality showing the gradual protrusion of the posterior adductor muscle scar with increase in age. Figs. 5-8. *Atrina seminuda* Lamarck from Aransas Bay, Texas. A series to show the relatively smaller posterior adductor muscle scar and its inclusion within the nacreous area. All drawings were made with the aid of a Berville camera lucida.

under this species Linné in the *Systema Naturae*, ed. 10, p. 707, referred to “*Concha Pinna*” in Hasselquist,<sup>1</sup> making this the type by absolute tautonomy. This has upset a designation which has been understood for well over one hundred years. In addition, even Grant and Gale admitted that “there has been doubt about the recognition of *Pinna muricata* Linné.” Hanley (1855) discussed fully the confusion concerning this species and Winckworth (1929), following Hanley, stated that the original description of *muricata* Linné was a composite, but that Linné in the *Museum Ulricae* (1764, p. 545, no. 143) gave a recognizable description of this species and limited the references to Rumphius (1741, pl. 46, fig. M) and Gaultieri (1742, pl. 79, fig. D). The locality, “M. Mediterraneo,” as given by Linné in 1758 has long been considered in error as there is nothing in the Mediterranean which approaches his description. Thus, the name *muricata* Linné had been restricted to the Indo-Pacific species and the reference to Hasselquist eliminated.

Therefore, considering the confusion as to the identity of *P. muricata* Linné, the subsequent limitation of the name by both Linné and Winckworth, and especially the fact that the Hasselquist reference was to a species which no one has been able to recognize, we agree with Iredale (1939) and Habe (1953) that the type species of *Pinna* Linné should remain *Pinna rudis* Linné, Gray 1847.

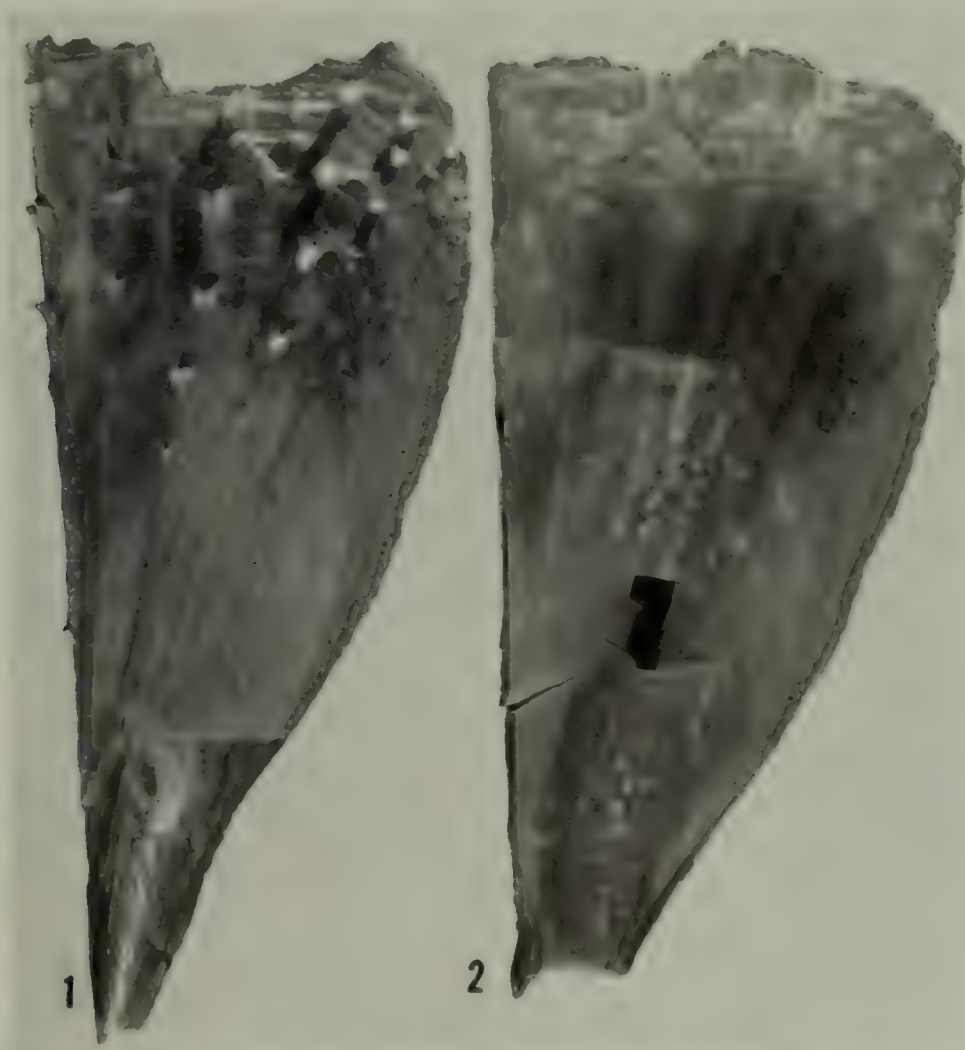


Plate 160. *Atrina* (*Servatrina*) *seminuda* Lamarck. Holotype specimen of *Pinna* (*Atrina*) *seminuda* Lamarck from Brasil. Fig. 1. External view of left valve. Fig. 2. Internal view of right valve (both natural size). Photographs courtesy of the Muséum d'Histoire Naturelle, Paris.

<sup>1</sup> Hasselquist, F. 1757, *Iter Palaestinum*, p. 448 [not 447 as given by Linné 1758], no. 137, Stockholm.

***Pinna rudis* Linné**

Plate 150, figs. 3-4; Plates 155, 156

*Pinna rudis* Linné 1758, Systema Naturae, ed. 10, p. 707 (O. Meridionali, Mediterraneo); Hanley 1855, Ipsa Linnaei Conchylia, p. 148; Dodge 1952, Bulletin American Museum of Natural History **100**, p. 223.

*Chimeroderma rude* Poli 1795, Testacea Utriusque Siciliae **2**, p. 259.

*Pinna ferruginea* Röding 1798, Museum Boltenianum, p. 160 (refers to Chemnitz **8**, pl. 88, fig. 773).

*Pinna elongata* Röding 1798, Museum Boltenianum, p. 160 (refers to Chemnitz **8**, pl. 88, fig. 773).

*Pinna pernula* Röding 1798, Museum Boltenianum, p. 160 (refers to Chemnitz **8**, pl. 92, fig. 785, St. Croix, Virgin Islands).

*Pinna varicosa* Lamarck 1819, Histoire Naturelle des Animaux sans Vertèbres **6**, p. 133 (l'île de la Trinité [Trinidad, Lesser Antilles]).

*Pinna paulucciae* de Rochebrune 1883, Bulletin de la Société Philomathique de Paris (7) **7**, p. 181 (estuary of Casamance River, Sénégal); Lamy 1911, Bulletin Muséum d'Histoire Naturelle, Paris **17**, p. 319.

**Description.** Shell reaching 565 mm. (about 22 inches) in length, wedge-shaped, sub-inflated, with a weak to moderately strong longitudinal keel at the anterior end. Valves thin in young specimens, but reaching a thickness of 3.5 mm. in large adults which are sculptured with radiating ribs. Shells translucent, particularly in young specimens, and ranging in color from a red-orange to a dark, reddish brown. Surface generally glossy. Sculpture consisting of from 5 to 8 strong, radiating ribs which support large tubular spines which open posteriorly. Concentric sculpture consisting of inconspicuous growth lines. Posterior margin irregular, but usually evenly rounded, with occasional specimens being truncate. Dorsal margin usually straight. Ventral margin convex posteriorly, concave anteriorly. Interior of the valves a deep red-orange and glossy. Nacreous layer iridescent and extending from the anterior end of the shell to the posterior margin of the posterior adductor muscle scar. The nacreous layer is divided by a longitudinal sulcus which extends anteriorly about two-thirds the distance to the anterior adductor muscle scar. The dorsal lobe of the nacreous layer is usually considerably longer than the ventral lobe, though in young specimens the lobes may be of about the same length. The posterior margin of the ventral lobe is usually nearly straight, while that of the dorsal lobe usually has an embayment dorsal to the muscle scar. Anterior adductor muscle scar small, subapical and nearly as wide as the valve. Posterior adductor muscle scar large, oval in outline, bounded posteriorly by the end of the nacreous layer and ventrally by the longitudinal sulcus. Primary hinge ligament thin, black and extending from the anterior end of the shell to the posterior border of the nacreous layer. Secondary ligament not colored but evident in fresh specimens, the dorsal margins of which are fused throughout: usually in dried specimens the valves gape from the end of the primary ligament to the posterior margin. Embryonic valves subtriangular, not inflated, the umbos small, posterior to the center and directed slightly posteriorly (Plate 150, figs. 3-4).

length	width	
565 mm.	175 mm.	Pointe Noire, Gaboon, French Equatorial Africa
420	185	" " " " " "
300	113	West Africa
192	93	" "
161	70	Gorée, Sénégal, French West Africa
139	65	Tobago, Lesser Antilles
202	90	Holotype of <i>Pinna varicosa</i> Lamarck, Trinidad, Lesser Antilles; measurements according to Lamy.

*Types.* According to Hanley (1855) and Dodge (1952) there is no specimen of *Pinna rudis* in the Linnaean collection. Linné's reference was to d'Argenville 1742, l'Histoire Naturelle, pl. 25, fig. F, which we here select as the type figure. It is a poor figure, but combined with Linné's description could certainly refer to this species. Hanley stated that the name *rudis* has generally been associated with the figure of Chemnitz (1785) in the Conchylien-Cabinet 8, fig. 773. The type locality was given by Linné as the Mediterranean Sea. The type of *Pinna paulucciae* de Rochebrune is in the Muséum d'Histoire Naturelle, Paris, according to Lamy (1911, p. 319). The type of *Pinna varicosa* Lamarck is also in the Paris Museum and the type locality is Trinidad. Lamarck's type is a stunted specimen, typical of *P. rudis* of the West Indies. Through the kindness of Dr. J. Gaillard of the Muséum d'Histoire Naturelle, Paris, we are able to figure the holotype specimen (Plate 156). Röding made reference to Chemnitz 8, pl. 88, fig. 773 under both *Pinna ferruginea* and *P. elongata*, and this figure is here selected as the type

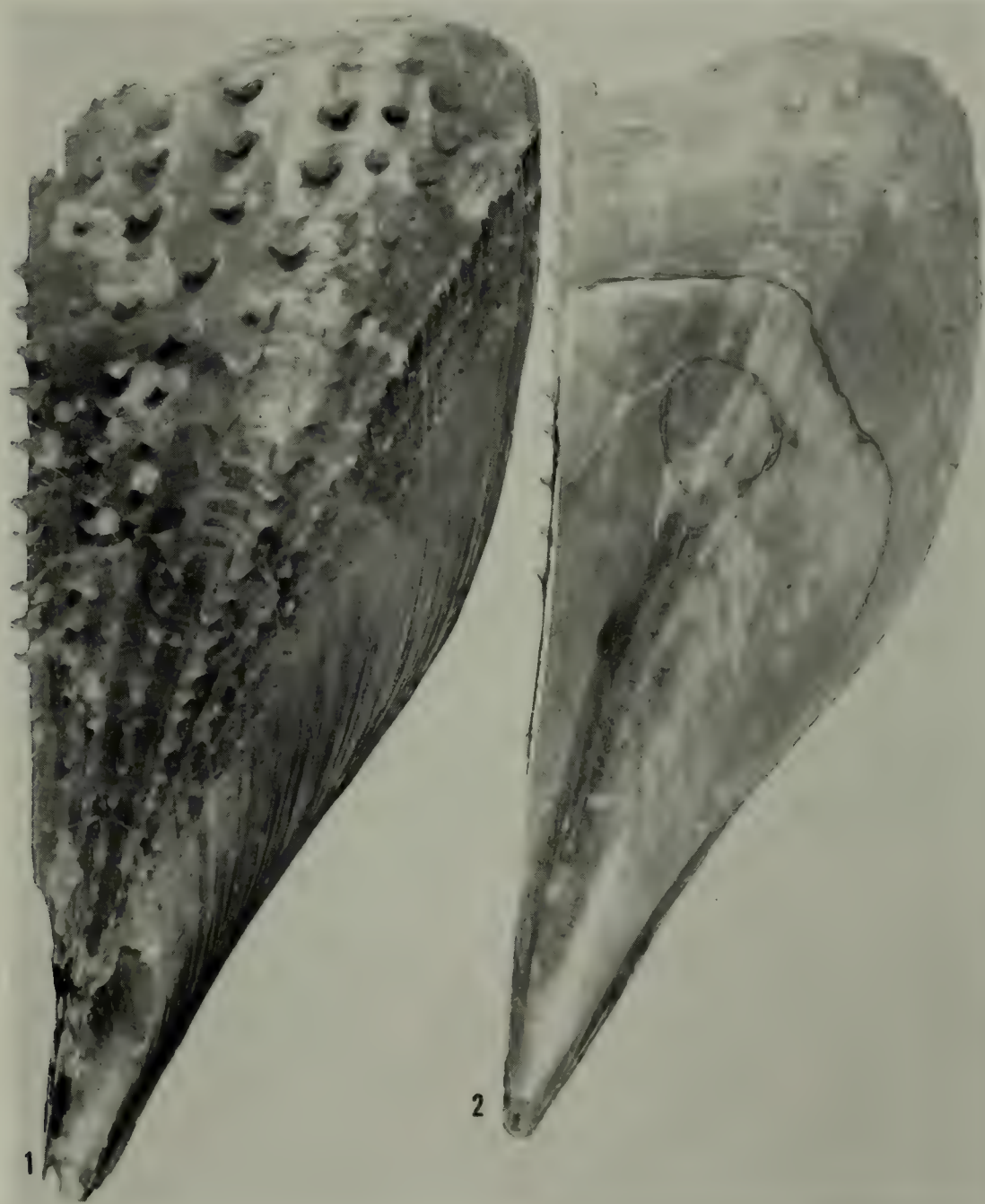


Plate 161. *Atrina (Servatrina) seminuda* Lamarck. Fig. 1. External view of the left valve of a specimen from Peruihybe, Itanhaem, São Paulo, Brasil, showing the smooth ventral slope and the open flute-like spines. Fig. 2. Internal view of right valve of a specimen from Itanhaem, São Paulo, Brasil, showing the well-inset muscle scar (both slightly enlarged).

figure for these two names. The type figure, here selected, of *P. pernula* Röding is Chemnitz 8, pl. 92, fig. 785, the only figure to which Röding referred. The type locality of *P. pernula* is St. Croix, Virgin Islands, those of the other two Röding names are unknown.

*Remarks.* See also *Remarks* under *Pinna carnea* Gmelin. As indicated in the measurements, *Pinna rudis* in the Eastern Atlantic is a large, robust species. It is closely related to *carnea* Linné and the young are easily confused with that species. However, in *P. rudis*, the dorsal lobe of the nacreous layer usually extends well posterior to the ventral lobe, with occasional specimens, particularly young, having the two lobes of equal length. In *P. carnea* the two lobes may be about equal in length, but usually the dorsal lobe is shorter than the ventral lobe. The ventral lobe of the nacreous layer is usually truncate in *rudis*, while in *carnea* it is rounded to pointed.

We have seen three lots of *P. rudis* from the Western Atlantic. All are small and deformed and they appear to have been living under adverse conditions. There are a number of records of Pinnidae taken from floating logs, ship bottoms, buoys and other such objects and the few records of *rudis* from the West Indies are apparently the result of such mechanical transport. Though these introduced adults may spawn, conditions for the growth of the young are apparently unsatisfactory for, to our knowledge, no lasting colony of this species has ever been established in the West Indies. Specimens of *P. rudis* in the West Indies are a much darker red-orange and have a more solid shell than specimens of *P. carnea* of the same size.

In the synonymy of *Pinna rudis* Linné we have included only those names which we considered were without question synonyms of *rudis*. There has been so much misidentification and misinterpretation of *rudis* Linné as well as other species in the Eastern Atlantic that if we included a reference to each of the misidentifications, the synonymy would become meaningless.

*Range.* EASTERN ATLANTIC: Western Mediterranean, Madeira, Canary and Cape Verde Islands, and the Atlantic coast of Africa south to St. Paul-de-Loanda, Angola.

WESTERN ATLANTIC: Occurs sporadically in Puerto Rico and the Virgin Islands south to Trinidad and Tobago, Lesser Antilles.

*Specimens examined.* EASTERN ATLANTIC: CANARY ISLANDS: Ténériffe (MCZ). FRENCH WEST AFRICA: Gorée, Sénégal (A. Humes). FRENCH EQUATORIAL AFRICA: Pointe Noire, Gaboon (A. Humes). BELGIAN CONGO: Banana (SDM). ANGOLA: St. Paul-de-Loanda (MCZ).

WESTERN ATLANTIC: PUERTO RICO: Aguadilla (A. Phares). VIRGIN ISLANDS: Christiansted, St. Croix (G. Usticke). LESSER ANTILLES: Tobago (MCZ); Trinidad (Muséum d'Histoire Naturelle, Paris).

### *Pinna carnea* Gmelin

Plates 149; 150, figs. 1-2; 151; 157

*Pinna carnea* Gmelin 1791, Systema Naturae, ed. 13, 1, p. 3365 (no locality given) [refers to Knorr 1771, Verlostigung 2, pl. 23, fig. 1].

*Pinna degenera* Link 1807, Beschreibung der Naturalien-Sammlung der Universität zu Rostock, p. 159 (no locality given) [refers to Chemnitz 8, pl. 87 [not 86 as given in Link], fig. 769].

*Pinna flabellum* Lamarck 1819, Histoire Naturelle des Animaux sans Vertèbres **6**, p. 130 [in part, references to Chemnitz **8**, pl. 86 [87], fig. 769, and to *Pinna carnea* Gmelin].

*Description.* Shell reaching 270 mm. (about 11 inches) in length, wedge-shaped, sub-inflated, with a weak to moderately strong longitudinal keel at the anterior end; valves thin, fragile, and sculptured with radiating ribs. Shell translucent, particularly in young specimens, and ranging in color from light tan to pink and salmon with occasional specimens becoming rather dark orange-brown. Surface generally glossy (except where incrustated with organisms and mud). Sculpture consisting of from 8 to 12 moderate to strong radiating ribs, often with intermediate riblets. These ribs may be smooth or provided with a few hollow spines which open posteriorly. Concentric sculpture consisting of inconspicuous lines of growth which are convex posteriorly. Posterior margin irregular, usually undulate and frequently fractured; it is convex, oblique or nearly straight. Dorsal margin variable, ranging from broadly concave to nearly straight. Ventral margin convex to slightly concave, but usually convex posteriorly and concave anteriorly. In some specimens it may be nearly straight. Interior of valves glossy and light tan to

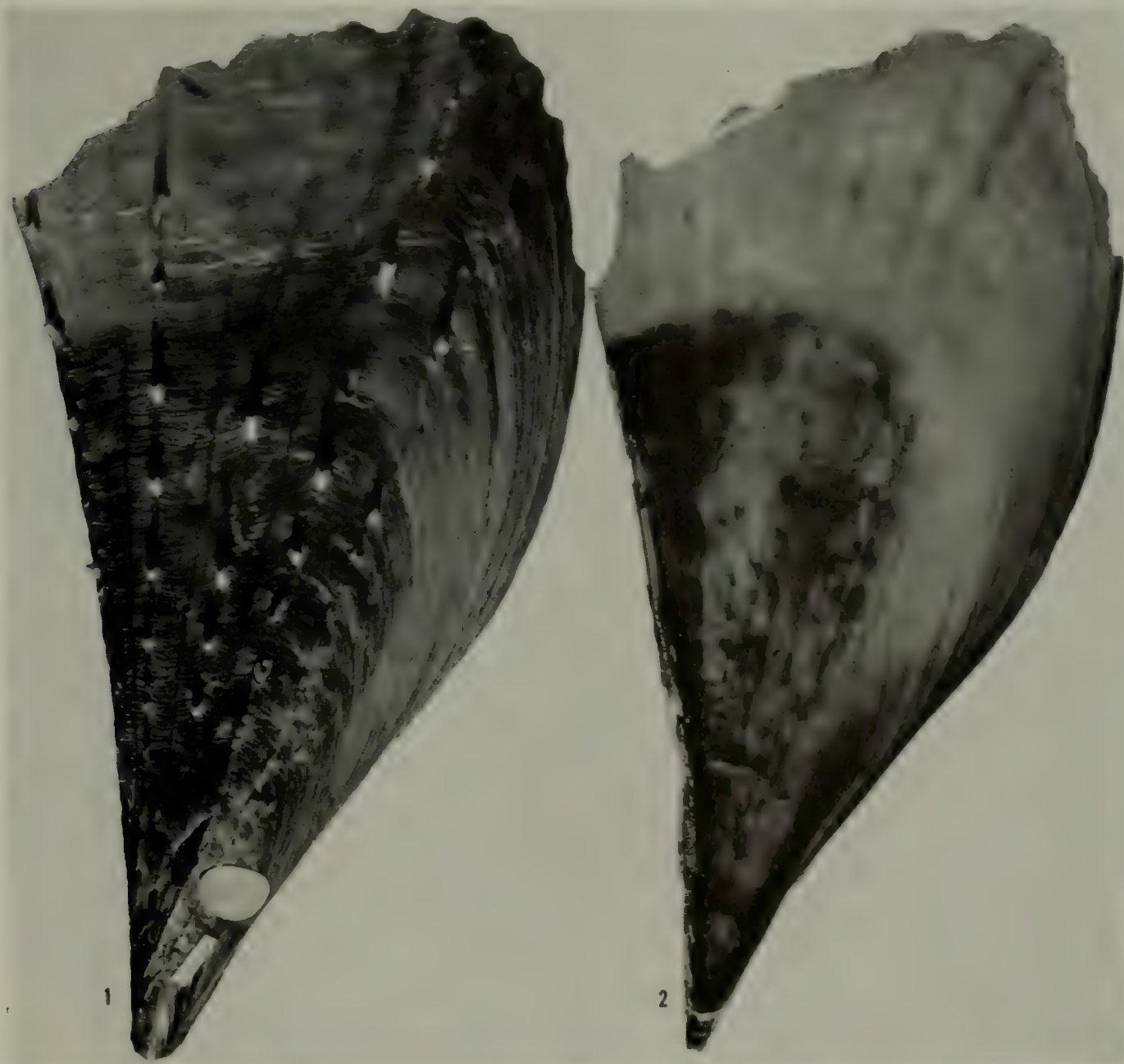


Plate 162. Holotype of *Pinna listeri* d'Orbigny [= *Atrina seminuda* Lamarck] from Brasil (about  $\frac{3}{5}$  natural size). Photograph courtesy of the British Museum (Natural History).

salmon or orange-brown in color. Nacreous layer iridescent and extending from the anterior end of the shell to and including the area of the posterior adductor muscle scar. It is divided by a longitudinal sulcus which extends nearly to the anterior end of the valve. Ventral lobe of the nacreous layer usually rounded and longer than the dorsal lobe though in young specimens the two lobes are often approximately equal in length. Anterior adductor muscle scar small, nearly as wide as the valve and located just anterior to the termination of the longitudinal sulcus. Posterior adductor muscle scar large, bounded posteriorly by the end of the nacreous layer and ventrally by the longitudinal sulcus. Primary hinge ligament thin, black and extending from the anterior end of the shell to the posterior border of the nacreous layer. Secondary ligament not colored but evident in fresh specimens, the dorsal margins of which are fused throughout; not usually seen in dried specimens the valves of which often gape from the end of the primary ligament to the posterior margin. Embryonic valves triangular, not inflated, the umbos central, prominent and directed medially (Plate 150, figs. 1-2).

length	width	
270 mm.	122 mm.	Bermuda
258	121	Alice Town, N. Bimini Id., Bahama Islands
247	108	Fish Point, Guantánamo Bay, Cuba
192	99	West Summerland Key, Florida
92	55	St. Thomas, Virgin Islands

*Types.* Gmelin's only reference under *Pinna carnea* was to Knorr 1771, pl. 23, fig. 1, and this is the type figure. The type locality is here designated as Guantánamo Bay, Cuba, an area from which we have seen material and from which specimens could have reached Europe at that early date.

*Remarks.* There has been considerable discussion concerning the species of *Pinna* in the Western Atlantic. This has arisen from the fact that species in this genus are variable, that *carnea* Gmelin of the Western Atlantic and *rudis* Linné of the Eastern Atlantic are close in their relationship and that young or worn specimens are difficult or even impossible to distinguish. When reviewing the literature for this group it was found that about half of the authors referred to all Western Atlantic specimens as *carnea* while others considered them to be *rudis*; still others have considered that both species are found here side by side. We agree with Dodge (1952) and Abbott (1954) that the common species throughout the West Indies is *Pinna carnea* Gmelin, though *rudis* does occur rarely in Puerto Rico and the Lesser Antilles. Though the West Indian specimens of *rudis* are small and usually lack spines they are readily distinguished by the pattern of the nacreous layer and muscle scar. *Pinna rudis* Linné in the Eastern Atlantic is a large, heavy species, having only 5-8 radiating ribs and much coarser spines than those of *carnea*. Specimens of *Pinna rudis* may reach 565 mm. in length and have spines 10.7 mm. wide at the base. The largest specimen of *carnea* in the collection of the Museum of Comparative Zoölogy is only 270 mm. in length with spines 4.5 mm. wide at the base. See *Remarks* under *P. rudis* Linné.

An interesting account of the anatomy and physiology of *Pinna carnea* is given by C. M. Yonge (1953). Structures peculiar to the Pinnidae in general are discussed and comparisons are made with other groups regarding form and evolution.

We have seen specimens of this species taken from a buoy off Key West, Florida and from the inside of an ocean buoy anchored just south of Miami. These specimens were all small (averaging about 50 mm. in length), thin, and medium to pale salmon in color. A single specimen taken from a buoy block from off Key West had reached a length of 180 mm. and was a normal *P. carnea* even though it had lived entirely on the surface of the block with no opportunity to burrow. This species, occurring as it does on buoys, must have a free swimming larval stage.

*Range.* From Lake Worth, Florida, south through the Florida Keys; Bermuda; the West Indies and from Veracruz, Mexico south probably to Trinidad.

*Specimens examined.* FLORIDA: South Inlet, Lake Worth (MCZ; USNM); Crandon Park, Miami; off Miami from the inside of an ocean buoy (both R. Merrill); Biscayne Key (J. K. Howard; J. Schwengel); 4 miles NE of The Elbow, Key Largo in 66 fathoms; off Carysfort Light, Key Largo (both MCZ); reef off Teatable Key (Peabody Mus., Yale Univ.; J. Schwengel; ANSP); Tavernier Key (R. Flipse); Little Duck



Plate 163. Holotype of *Pinna subviridis* Reeve [= *Atrina seminuda* Lamarck] from South Carolina (about  $\frac{1}{2}$  natural size). Photograph courtesy of the British Museum (Natural History).

Key (MCZ; G. Kline); Grassy Key (MCZ; ANSP; G. Kline); Pigeon Key; Missouri Key; Ohio Key; West Summerland Key (all D. and N. Schmidt); Key Vaca (J. Schwengel; D. and N. Schmidt); Big Pine Key (MCZ); Looe Key (J. Schwengel); Key West (MCZ; ANSP; USNM; CAS); off Key West from a buoy (R. Merrill); Fort Jefferson, Dry Tortugas (MCZ); Bird Key and Garden Key, Dry Tortugas (both USNM). BERMUDA: Richardson Inlet, St. George Island (MCZ); Castle Harbour in 4–5 fathoms (R. Foster). BAHAMA ISLANDS: West End, Grand Bahama (MCZ); Hope Town, Great Abaco (G. Kline); south end, Elbow Cay, Great Abaco (R. Robertson); Alice Town, North Bimini Id. (MCZ; ANSP); North Cat Cay, Bimini Islands (J. Schwengel); South Riding Rock, 30 miles S of Bimini Island; NW coast South Bimini (both R. Robertson); Nassau, New Providence (Peabody Mus., Yale Univ.; USNM); Adelaide Beach, New Providence (R. Robertson); Sandy Point, Savannah Sound, Eleuthera (ANSP; MCZ); Port Royal; Arthurs Town and Northeast Point, all Cat Island; Little San Salvador, 18 miles W of Cat Island; Matthew Town, Great Inagua (all MCZ); Big Wood Cay, Andros; George Town, Exuma (both G. Kline); Hog Cay, Exuma (R. Robertson). CUBA: Cabo Cajon, Pinar del Río; Cayo Jutia and Bahía de Cabañas, Pinar del Río (all MCZ); Cayo Francés, Caibarién, Las Villas (P. J. Bermudez; R. Humes); Castillo de Jagua, Bahía de Cienfuegos, Las Villas (ANSP); Caletón de Don Bruno, 4 miles SW of Cienfuegos and Punta de la Milpa, Cienfuegos, both Las Villas (both MCZ); Cayo off Punta San Juan, Bahía de los Perros, Camagüey (ANSP); Cable Beach and Fish Point, Guantánamo Bay, Oriente (both MCZ). JAMAICA: Port Royal (USNM). HISPANIOLA: South of Punta Mangle, Bahía de Samaná, Dominican Republic (USNM). PUERTO RICO: Aguadilla and Mayagüez (both A. Phares); Punta Algorrobo and Punta Guanajibo (both G. Warmke); Culebra Island (USNM). VIRGIN ISLANDS: near Christiansted, St. Croix (G. Usticke); St. Thomas (MCZ; USNM; San Diego Mus.); St. John (ANSP; USNM); Tortola and Guana Island (both MCZ); Gorda Sound, Virgin Gorda (R. Foster). LESSER ANTILLES: Saint Martin (ANSP); Antigua (ANSP; USNM); Barbados (MCZ; Peabody Mus., Yale Univ.; USNM; ANSP); Tobago (MCZ). CARIBBEAN ISLANDS: Old Providence Island (USNM). MEXICO: Veracruz, Veracruz (T. Pulley; USNM). COLOMBIA: Cartagena (CAS; SDM); Santa Marta (USNM).

### Genus *Atrina* Gray

*Atrina* Gray 1840, Synopsis Contents of the British Museum, ed. 42, p. 151 [nomen nudum]; Gray 1842, Synopsis Contents of the British Museum, ed. 44, p. 83 [described but no species listed]; Gray 1847, Proceedings Zoological Society of London, p. 199.

*Pennaria* 'Browne' Mörch 1853, Catalogus Conchyliorum Comes de Yoldi, part 2, p. 51 (type species, *P. rigida* Solander [= *Atrina rigida* Solander] here selected), non *Pennaria* Oken 1815, non de Blainville 1818.

*Pinnaria* 'Browne' Paetel 1890, Catalog der Conchylien-Sammlung, p. 208 [error for *Pennaria* Browne].

Type species, *Pinna nigra* 'Chemnitz' Dillwyn, by subsequent selection, Gray 1847.

Shell reaching about 350 mm. (14 inches) in length, wedge- or wing-shaped in outline. Thin to rather heavy in structure with terminal umbos and often sculptured with imbricated radiating ribs. Nacreous layer extending about two thirds to three fourths the length of the shell and not divided by a longitudinal sulcus. The large posterior adductor muscle scar located subcentrally.

Species in this genus are found in nearly all tropical and subtropical seas with a few species reaching warmer temperate waters.

### Subgenus *Atrina* Gray

The external features of the species included in this subgenus are similar to those of the genus as a whole. The characteristic feature of the subgenus is the protrusion of the posterior adductor muscle scar beyond the posterior margin of the nacreous area (Plate 159, figs. 1-4).

There is only one species in this subgenus in the Western Atlantic, *Atrina rigida* Solander.

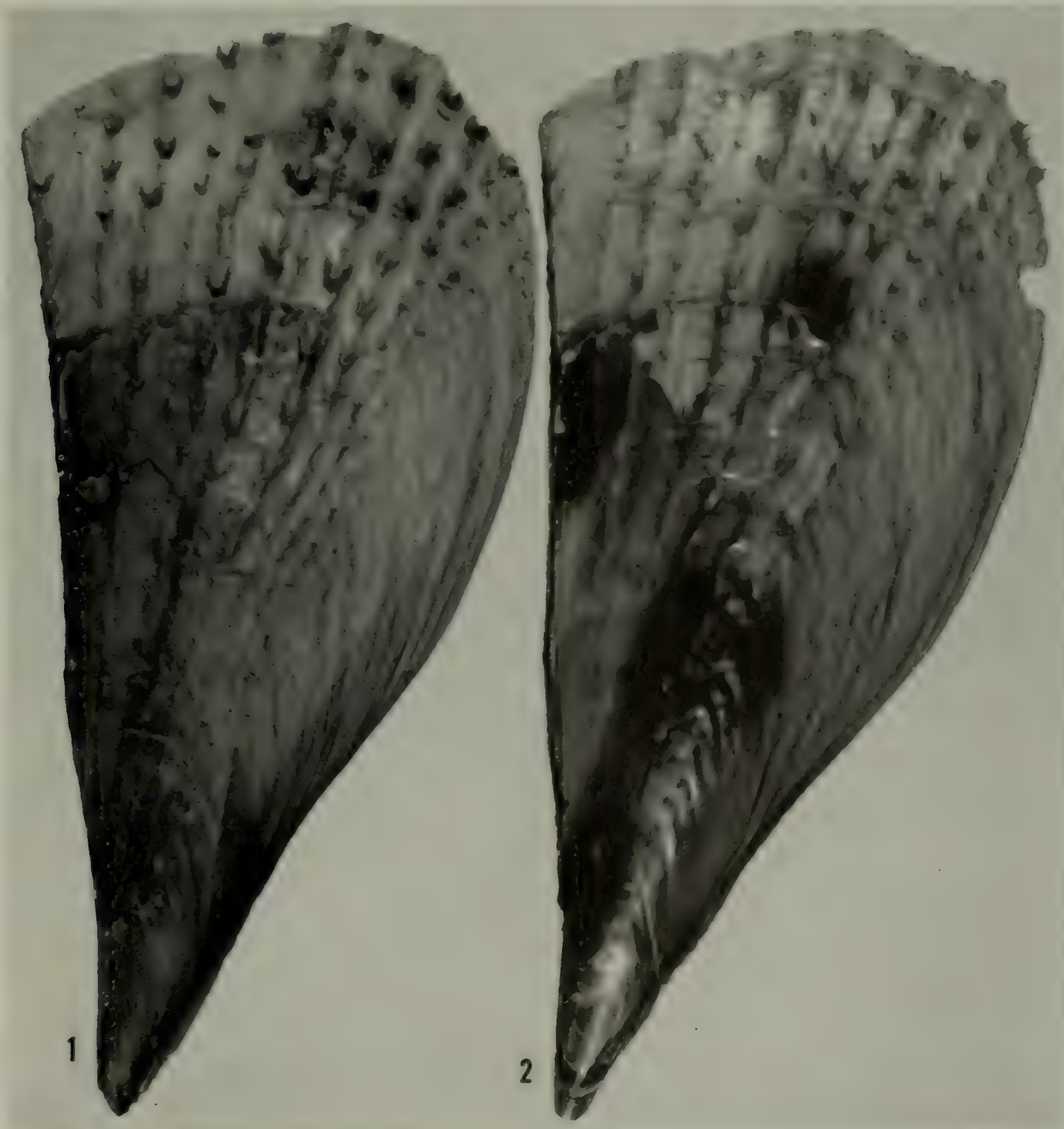


Plate 164. *Atrina* (*Serratina*) *seminuda* Lamarck from Bogue Island, North Carolina (about  $\frac{3}{4}$  natural size). A typical specimen showing the smooth ventral slope (fig. 1) and the thin, translucent quality of the shell often evident in this species (fig. 2).

***Atrina (Atrina) rigida* Solander**

Plates 158; 159, figs. 1-4

*Pinna rigida* Solander 1786, Catalogue of the Portland Museum, p. 136, species 3040 (no locality given) [refers to Knorr 1771, pl. 26, fig. 1].

*Pinna carolinensis* Hanley 1858, Proceedings Zoological Society London, p. 225 (Carolina Amer. Sept.); Reeve 1848, Conchologia Iconica 11, **Pinna**, pl. 34, fig. 66.

**Description.** Shell large, reaching about 286 mm. (about  $11\frac{1}{2}$  inches) in length, wedge-shaped, usually somewhat inflated, thin, fragile and sculptured with spinose radiating ribs. Shell translucent, ranging in color from a purplish brown to nearly black, but all specimens when viewed with transmitted light are a mottled golden to rich red-brown. Surface generally dull, particularly in older specimens. Sculpture variable, ranging from specimens which are nearly smooth to those having numerous ribs. The sculpture on the posterior slope consists of from 6 to 17 ribs which usually bear large, slightly recurved, tubular spines which may reach 15 mm. in length. Young specimens may have only 3 to 4 ribs; the additional ribs are intercalated as the shell grows in size. Sculpture on the ventral slope variable, ranging from rather heavy spines to fine imbrications. Concentric sculpture consisting of irregular lines of growth. Posterior margin irregular, usually rounded but frequently fractured. Dorsal margin usually slightly concave. Ventral margin strongly convex posteriorly and concave anteriorly. Interior of the valves iridescent, somewhat mottled, dark greenish brown to purple-black, usually greenish around the edges. Nacreous layer extending about two thirds the length of the shell. The large nearly circular posterior adductor muscle scar is situated at the posterior end of the nacreous layer, its posterior margin protruding beyond it. The extent of protrusion varies and increases with the age of the shell. Anterior adductor muscle scar small and nearly as wide as the anterior end of the shell.

In living specimens the posterior, thickened margin of the mantle is black with small, irregular white vermiculations; the ventral margin is a gray-white. Inside this thickened margin the mantle is a bright golden orange. It is most intense near the margin, fading to a pale orange at the waste canal. The ctenidia are a medium to pale translucent orange-buff. The pallial organ, even when contracted, has a large conical "head" which is an opaque cream color. The stalk of the pallial organ is a translucent grayish ivory. The foot is cream colored. The sexes are separate and are readily distinguished—the testes being a cream-white and the ovaries a medium magenta.

length	width	
286 mm.	180 mm.	Gulfport, Florida
237	133	Beaufort, North Carolina
235	128	Cayo Francés, Caibarién, Cuba
230	144	Off Pan American Airport, Coconut Grove, Florida
226	158	Alice Town, North Bimini Id., Bahama Islands
215	111	Chadwick Beach, Lemon Bay, Florida
177	97	Santa Barbara de Samaná, Dominican Republic

**Types.** The location of the type specimens of *Pinna rigida* Solander is unknown to us. Solander referred to Knorr 1771, pl. 26, fig. 1, which we here consider the type figure. The type of *Pinna carolinensis* Hanley may be in the British Museum (Natural History), though Wilkins (1953) does not list it. The type locality is here restricted to Beaufort, North Carolina.

*Remarks.* This is a common species in the Florida region. It is close in appearance to *Atrina seminuda* Lamarck with which it has generally been confused. Externally, the two species often cannot be separated, but the relative positions of the muscle scar and the nacreous layer readily differentiate them. In *Atrina rigida* the posterior adductor muscle scar is proportionately larger in relation to the size of the shell. The posterior margin of the muscle scar is continuous with the posterior border of the nacreous area, and in older specimens, protrudes well beyond it (Plate 159, figs. 1-4). In *Atrina seminuda* Lamarck the muscle scar is set within the nacreous area with a border of nacreous material margining it posteriorly (Plate 159, figs. 5-8). Other characters used in separating *rigida* and *seminuda* are often less definite. However, *A. rigida* generally has a heavier shell, which is rounded rather than truncate posteriorly and its dorsal border is often slightly concave rather than straight as in *seminuda*. *Atrina rigida* is usually more spinose, particularly on the ventral slope which is generally smooth in *A. seminuda*. In color, the shell of *A. rigida* is far darker, usually being a purple-black in adult specimens, while in *seminuda* it is mottled tan and purple. If living material is available *rigida* may be readily separated from *seminuda* by the color of the soft parts. The most conspicuous difference is the bright golden-orange mantle coloration of *rigida* while the same area is

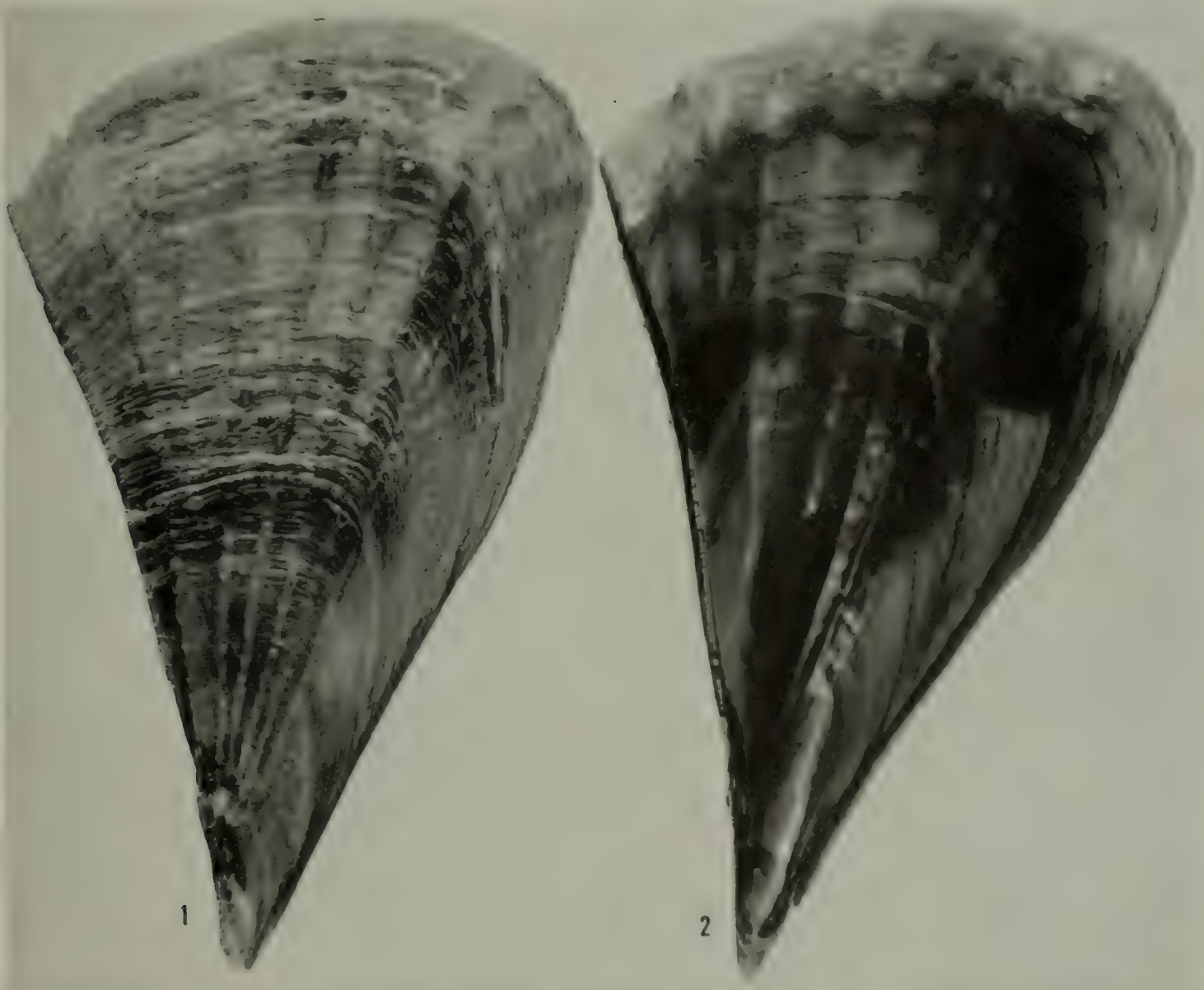


Plate 165. *Atrina* (*Servatrina*) *seminuda* Lamarck from Port Isabel, Texas. Fig. 1. Outer surface of a typical specimen from the Texas area showing the nearly smooth, almost spineless valves and the truncate posterior margin. Fig. 2. Inner surface showing the dark color of the shells from this area (both about  $\frac{3}{4}$  natural size).

a pale yellow in *seminuda*. The gills of *rigida* are a pale orange-buff while those of *seminuda* are intense brownish orange. The "head" of the pallial organ of *rigida* is large and conical while that of *seminuda* is small and rounded. See *Remarks* under *A. seminuda* Lamarck.

An account of the anatomy and physiology of *Atrina rigida* is given by Grave (1911). This species is usually found living in sandy mud from the intertidal area to depths of about three to fifteen fathoms. Specimens are very abundant in certain areas and may be a real hazard to fishermen who report that their nets are often badly torn when dragging over a bed of *Atrina*.

*Atrina tuberculosa* Sowerby is the Eastern Pacific analogue of this species, though it is a larger and heavier shell. It is known mainly from the Gulf of California, ranging from Puerto Peñasco, Sonora to La Paz, Baja California, Mexico.

*Range.* From Cape Hatteras, North Carolina, south through the Florida Keys and the west coast of Florida as far north as Panama City; the Bahamas; Cuba and Hispaniola. This species apparently does not occur on the northern Gulf coast, in Texas or in Central America.

*Specimens examined.* NORTH CAROLINA: Buxton, Cape Hatteras (USNM); Beaufort (MCZ; San Diego Mus.); Wilmington (MCZ); Smith Island, Cape Fear (ANSP). FLORIDA: Jacksonville Beach; Daytona Beach; New Smyrna; Cape Canaveral (all MCZ); Lake Worth (G. Kline; MCZ; ANSP; USNM; San Diego Mus.); off Hillsboro Inlet, Pompano (MCZ); Crandon Park, Miami (R. Merrill); Biscayne Bay (ANSP; R. Work); Key Biscayne, Miami (J. K. Howard); Little Pine Key and Grassy Key (both ANSP); Sandy Key, Cape Sable (USNM); off Everglades (MCZ); Cape Romano (ANSP); Bonita Beach, Bonita Springs (MCZ); Punta Rassa (D. and N. Schmidt); Sanibel Island (MCZ; ANSP; J. S. Schwengel; San Diego Mus.); Captiva Island (MCZ; J. S. Schwengel); Boca Grande, Gasparilla Id. (ANSP); Chadwick Beach, Lemon Bay (MCZ); Long Key, off Sarasota (MCZ; USNM); Mullet Key, Tampa Bay; Boca Ciega Bay, St. Petersburg (both ANSP); St. Petersburg (USNM; San Diego Mus.); off Tampa Bay in 3-4 fathoms (H. Bullis); Gulfport (MCZ); Cedar Keys (USNM; CAS; SDM); near Sea Horse Key, Cedar Keys (MCZ; ANSP); St. Joseph Bay (ANSP); Panama City (USNM). BAHAMA ISLANDS: Rocky Point, East Bimini (R. Robertson); Alice Town, North Bimini Id. (MCZ). CUBA: Cayo Francés, Caibarién, Las Villas; Fish Point, Guantánamo Bay (both MCZ); Cayo Galindo, Cárdenas, Matanzas (ANSP). HISPANIOLA: Santa Barbara de Samaná, Dominican Republic (MCZ).

### Subgenus *Servatrina* Iredale

*Servatrina* Iredale 1939. Great Barrier Reef Expedition, Scientific Reports 5, no. 6, p. 317.

Type species, *Pinna assimilis* Reeve, by original designation.

Externally the shells are similar to those of other *Atrina*. The characteristic feature of the subgenus is found on the inner surface of the valves. The large posterior adductor muscle scar is enclosed completely within the nacreous area rather than protruding beyond it as in *Atrina* s.s.

The subgenus is world-wide in distribution in the warmer temperate and tropical seas.

***Atrina* (Servatrina) *seminuda* Lamarck**

Plates 150, figs. 5–6; 159, figs. 5–8; 160–169

*Pinna semi-nuda* Lamarck 1819, Animaux sans Vertèbres 6, pt. 1, p. 131 (les Mers d'Amérique); Lamy 1932, Bull. Muséum National d'Histoire Naturelle (2) 4, p. 896 (Brasil); non *P. seminuda* Bowdich 1825; non *seminuda* 'Lamarck' Reeve 1858.

*Pinna alta* Sowerby 1835, Proceedings Zoological Society London, p. 84 (Sinu Honduras); Reeve 1858, Conchologia Iconica 11, Pinna, pl. 6, fig. 11.

*Pinna listeri* d'Orbigny 1846, Voyage l'Amérique Méridionale 5, pt. 3, Mollusques, p. 641, pl. 85, fig. 1 (côtes du Brésil); Carcelles 1944, Revista del Museo de la Plata (n.s.) Zoologia 3, p. 278, pl. 10, fig. 77.

*Pinna patagonica* d'Orbigny 1846, Voyage l'Amérique Méridionale 5, pt. 3, Mollusques, p. 641, pl. 85, fig. 2 (l'embouchure du Rio Negro, Patagonie); Carcelles 1944, Revista del Museo de la Plata (n.s.) Zoologia 3, p. 278, pl. 10, fig. 78.

*Pinna subviridis* Reeve 1858, Conchologia Iconica 11, Pinna, pl. 17, fig. 32 (South Carolina).

*Pinna ramulosa* Reeve 1858, Conchologia Iconica 11, Pinna, pl. 28, fig. 52 (West Indies).

*Pinna d'orbignyi* 'Hanley' Reeve, Aug. 1858, Conchologia Iconica 11, Pinna, pl. 26, fig. 49 (West Indies); Hanley, Jan. [Nov.] 1858, Proceedings Zoological Society London, p. 228.

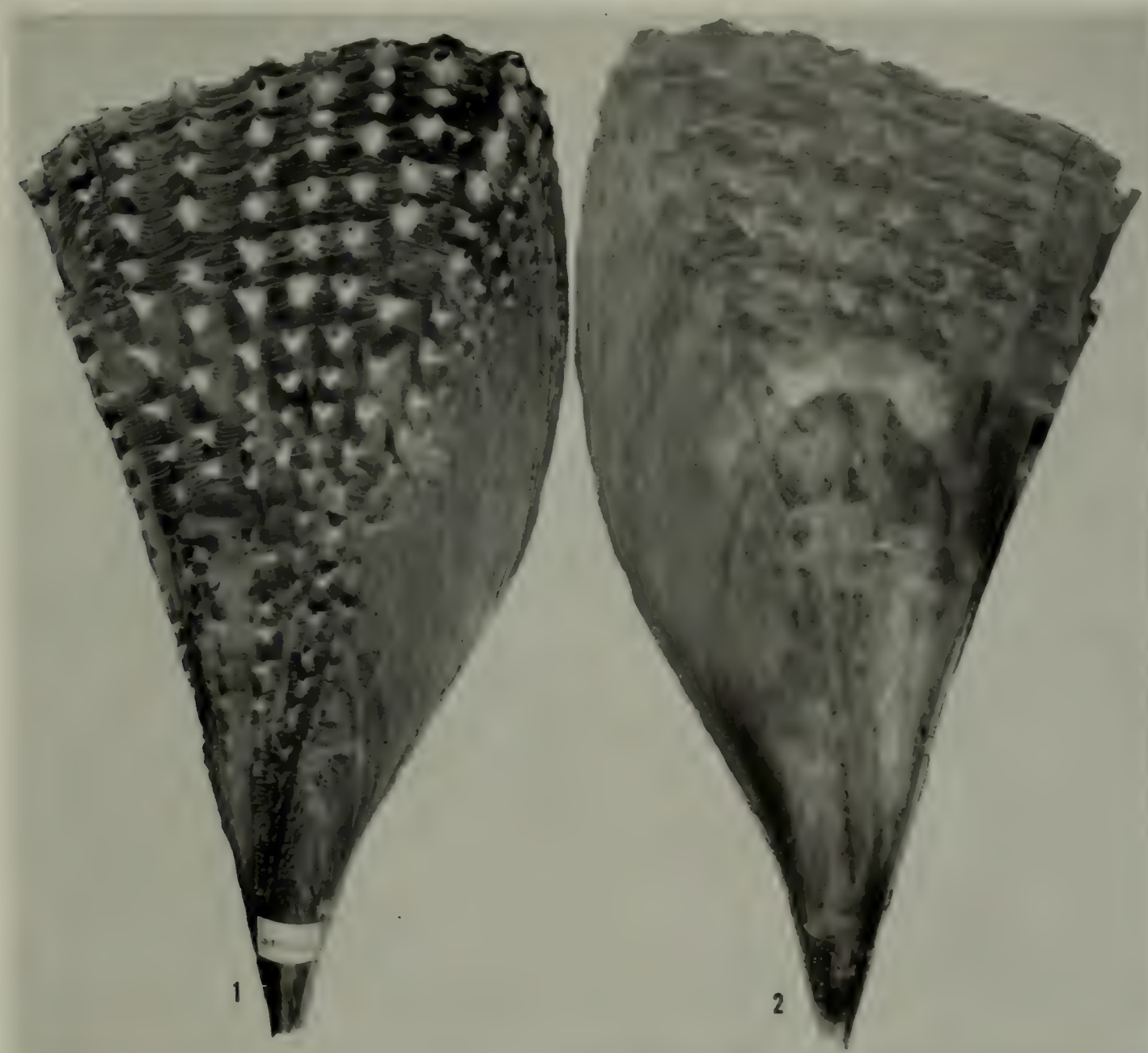


Plate 166. Holotype of *Pinna ramulosa* Reeve [= *Atrina seminuda* Lamarck] from the West Indies (about  $\frac{3}{4}$  natural size). Photograph courtesy of the British Museum (Natural History).

*Description.* Shell reaching 243 mm. (about  $9\frac{5}{8}$  inches) in length, wedge-shaped, usually somewhat inflated, thin, fragile and sculptured with spinose radiating ribs, but with the ventral slope usually smooth. Shell translucent, ranging in color from a uniform grayish tan to a mottled tan and purple or purple-brown, particularly when viewed with transmitted light. Surface usually somewhat glistening, particularly in young specimens. Sculpture variable, ranging from specimens which are smooth or nearly so to those having numerous, spinose, radiating ribs. The sculpture on the posterior slope consists of from 5 to 16 radiating ribs which may be smooth or armed with spines. These spines are usually tubular and slightly recurved, though on occasional specimens they appear as coarse, upright flutes. Sculpture on the ventral slope usually consisting of fine growth lines and indistinct radiating ribs, with occasional specimens having small spines near the posterior margin. Concentric sculpture consisting of irregular growth lines. Posterior margin irregular, usually somewhat truncated with a distinct angle at the union of the ventral slope and the posterior slope. Dorsal margin slightly concave. Ventral margin convex posteriorly and only slightly concave anteriorly. Interior of valves iridescent, ranging in color from a nearly uniform tan to a mottled tan and purple-brown. Nacreous layer extending about one half to two thirds the length of the shell. Posterior adductor muscle scar small in relation to the size of the shell, oval in outline and usually lying well within the nacreous area. In occasional specimens there is only a very narrow border of nacreous material edging the muscle scar posteriorly, but the muscle scar never protrudes beyond the nacreous area. Anterior adductor muscle scar small and nearly as wide as the anterior end of the shell. Embryonic valves subcircular, inflated, the umbos prominent and directed slightly posteriorly (Plate 150, figs. 5-6).

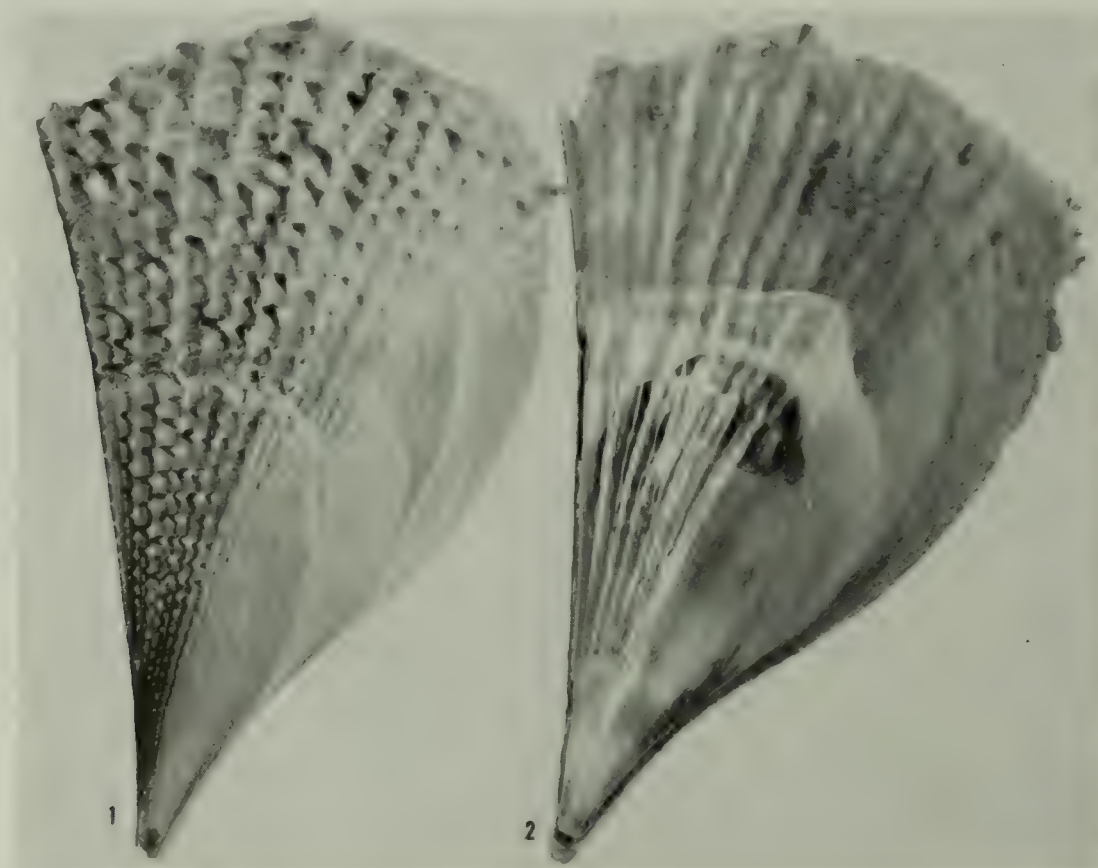


Plate 167. *Atrina (Servatrina) seminuda* Lamarck from Kingston, Jamaica. A specimen typical of this species in the West Indies, showing a slight broadening of the valves posteriorly and an increase in the number of radiating ribs and spines (about  $\frac{1}{3}$  natural size).

In living specimens the posterior and thickened margin of the mantle is black with reddish markings. Inside the margin the mantle is pale yellow, the color being most intense near the thickened margin, fading to white at the waste canal. The ctenidia are an intense brownish orange and very conspicuous. The pallial organ, when contracted, has a small rounded "head" which is a light salmon in color. The stalk of the pallial organ is a translucent white. The foot is light yellow. The sexes are separate—the ovaries are a bright pink-orange. A male specimen was not seen.

length	width	
243 mm.	125 mm.	Charleston, South Carolina
177	90	Aransas Bay, Texas
169	112	Kingston, Jamaica
151	92	West Trinidad
151	87	Gulfport, Florida
140	67	Tuxpan, Veracruz, Mexico
125	52	Itanhaem, Estado de São Paulo, Brasil

*Types.* The holotype of *Pinna seminuda* Lamarck is in the Muséum d'Histoire Naturelle, Paris. The type locality is Brasil according to Lamy (1932, p. 396). Through the kindness of J. Gaillard of the Paris Museum we are able to figure the holotype (Plate 160). The type locality is here restricted to Rio de Janeiro, Brasil.

The holotypes of the following species are all in the British Museum (Natural History): *P. listeri* d'Orbigny from Brasil, no. 1854.12.4.814; *P. alta* Sowerby from the Bay of Honduras, no. 1952.8.29.1; *P. ramulosa* Reeve from the West Indies, no. 1952.8.29.45; *P. subviridis* Reeve from South Carolina, no. 1952.8.29.62; and *P. d'orbignyi* Reeve

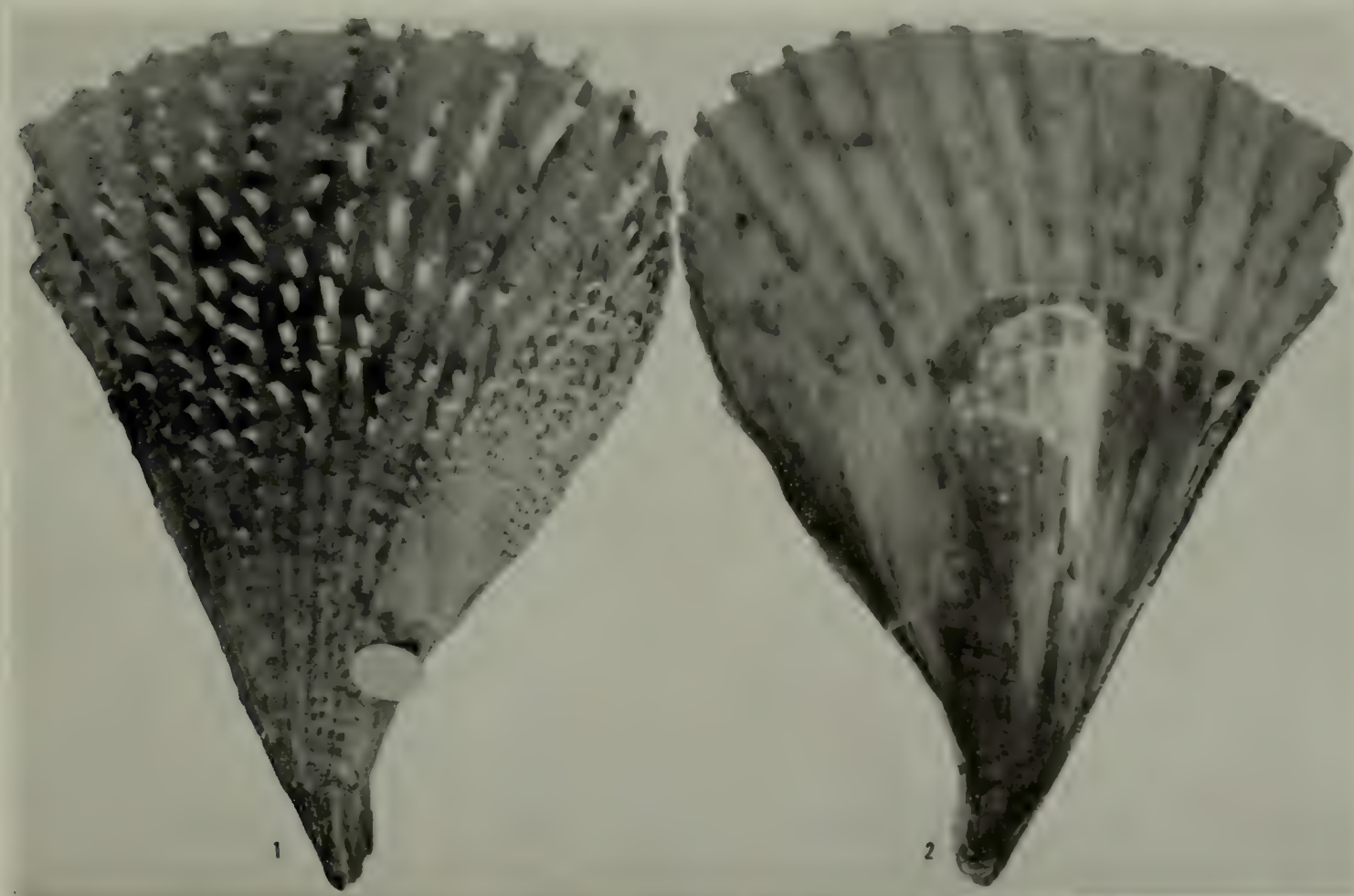


Plate 168. Paratype of *Pinna alta* Sowerby [= *Atrina seminuda* Lamarck] from the Bay of Honduras (about  $\frac{1}{2}$  natural size). An unusually broad form. Photograph courtesy of the British Museum (Natural History).

from the West Indies, no. 1952.8.29.15. Through the kindness of I. C. J. Galbraith of the Mollusca Section of the British Museum (Natural History) we are able to figure all of the above type specimens.

*Remarks.* *Atrina seminuda* Lamarck is a very variable species which has generally been considered a synonym of *A. rigida* Solander. However, on the basis of its muscle scars and the extent of the nacreous layer, it belongs in the same subgenus as *A. serrata* Sowerby. See *Remarks* under *A. serrata*. Externally, *A. seminuda* is often difficult to distinguish from *A. rigida*, and for this reason has long been confused with that species. There is no single, external character which will separate these two species for the range in variation of each overlaps with that of the other. In general, *seminuda* is lighter in color and less strongly sculptured, the ventral slope is usually devoid of spines and the valves are usually truncate posteriorly. The tremendous range of variation in the sculpture of *seminuda* appears to be largely a reflection of ecologic conditions. However, on the basis of the material which we have studied, there does seem to be an increase in the number of ribs and the size of the spines on specimens from near the center of the range. Specimens from Brasil and North Carolina are quite similar in appearance, while those from the West Indies are usually more spinose. Specimens from the Texas coast are generally darker in color, smoother, often being completely spineless, and more truncate than those from elsewhere in the range. The relationship of the width to the length of the shell in this species is also extremely variable, as is shown by the measurements and illustrations. *Atrina alta* Sowerby is an example of an unusually broad and spinose form while *d'orbignyi* Reeve is a young, elongate and spinose form. Wilkins (1953) believed the type locality of *d'orbignyi* Reeve to be in error and placed this species in the synonymy of *squamifera* Sowerby from South Africa. However, there are in the Museum of Comparative Zoölogy several specimens from the West Indian region which approximate the figure of the type specimen very closely (Plate 169). We therefore consider *d'orbignyi* Reeve to be a synonym of *seminuda*. The most dependable character to use in distinguishing *seminuda* from *rigida* is that of the position, size and relationship of the muscle scar and the nacreous layer. In Plate 159 we have indicated the change in position of the muscle scar with the growth of the shell for these two species. Young specimens and those which have grown rapidly are sometimes difficult to distinguish. In some fairly large specimens of *seminuda* the muscle scar is only slightly inset in the nacreous area while in some equally large but rapidly grown specimens of *rigida* the muscle scar has not protruded. However, in these cases, other characters, such as the general outline of the nacreous area, the shape of the shell and the lack of sculpture on the ventral slope aid in determining the species. The muscle scar of *seminuda* never protrudes beyond the nacreous area and it is usually much smaller in proportion to the size of the shell than that of *rigida*. If a series of specimens from a given locality is available there is no difficulty in determining the species and when working with animals that are so readily affected by their environment, as are all species of *Atrina*, large series are essential. When living material is available *seminuda* is readily differentiated by the coloration of the soft parts. See *Remarks* under *rigida*.

*Atrina maura* Sowerby is the Eastern Pacific analogue of this species. It is the most common species in the Eastern Pacific, ranging from Bahía Magdalena, Baja California, Mexico, south to Peru. This species is commonly eaten by the Mexicans.

*Range.* We are unable to account for the absence of *A. seminuda* in southern Florida, the Florida Keys and the Bahama Islands. Except for these areas, its range compares with that of *Laevicardium laevigatum* Linné, *Trachycardium muricatum* Linné and *Macrocallista maculata* Linné all of which extend from North Carolina to southern Brasil or Argentina.

*Specimens examined.* NORTH CAROLINA: Cape Lookout (USNM); Beaufort (ANSP; USNM); Bogue Id. (MCZ); Long Beach near Southport (USNM); Smith Id., Cape Fear (ANSP). SOUTH CAROLINA: 4 miles SW of Myrtle Beach (ANSP); Isle of Palms (MCZ); Sullivans Id. (CAS; MCZ); Charleston (MCZ). GEORGIA: Sea Id. Beach (ANSP); St. Simons Id. (USNM); Cumberland Id. (MCZ). FLORIDA: Amelia Id. (ANSP; USNM); St. Augustine (USNM); Anastasia Id., St. Augustine; Daytona Beach; Lake Worth (all ANSP); Coronado Beach (MCZ); Fort Myers Beach (ANSP); Sanibel Id. (J. S. Schwengel; ANSP); Captiva Id., and Indian Beach, Sarasota (both MCZ); St. Petersburg (USNM); Pass-a-grille, Pinellas Co. (MCZ); Clearwater Bay, Pinellas Co. (ANSP); Gulfport (SDM; MCZ); Panama City (USNM). ALABAMA: Dauphin Island (J. Foshee). LOUISIANA: American Bay, St. Bernard Parish (R. Parker); Grand Isle (MCZ); Freemason Id., Chandeleur Islands (D. Moore). TEXAS: Galveston

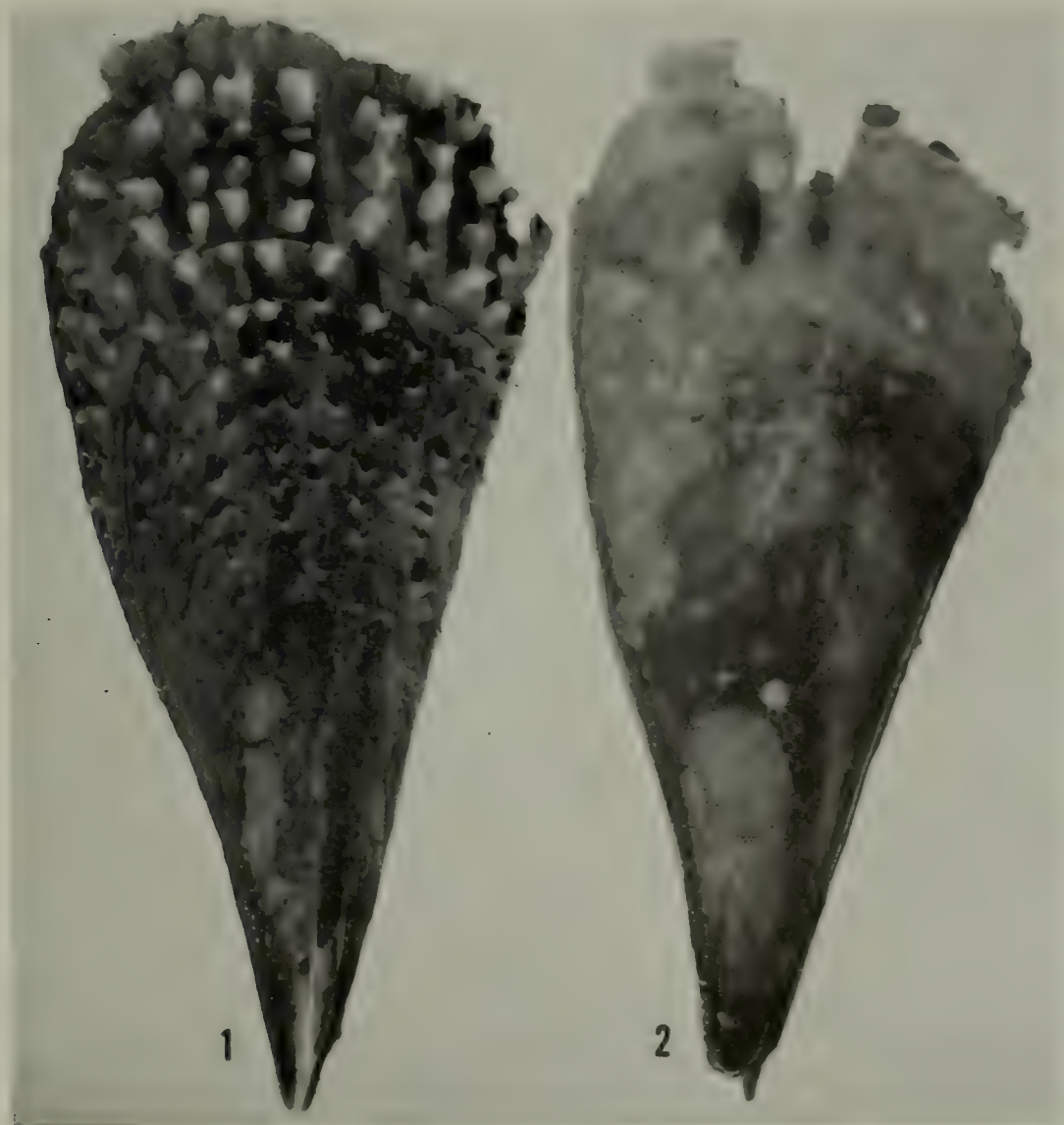


Plate 169. Holotype of *Pinna d'orbignyi* Reeve [= *Atrina seminuda* Lamarck] from the West Indies (natural size). Fig. 1. A young specimen which was probably growing in quiet water allowing unusual development of the spines. Fig. 2. Inner surface of the opposite valve which, though somewhat overgrown with Bryozoa, does show the muscle scar and nacreous layer. Photographs courtesy of the British Museum (Natural History).

(T. E. Pulley: USNM): San Luis Pass, Galveston (T. E. Pulley); Matagorda Bay (SDM; CAS: USNM); Indianola (USNM); Aransas Bay (J. L. Baughman; SIO; USNM); Port Isabel (E. Weisenhaus; R. Parker); Brownsville (MCZ); 60 miles S of Brownsville in 12-14 fathoms (C. L. Branch). CUBA: Varadero Beach, Matanzas (USNM). JAMAICA: Kingston (MCZ; ANSP; USNM); Rock Fort and Port Royal (USNM). HISPANIOLA: Port au Prince, Dépt. de l'Ouest; Les Cayes and Torbeck, Dépt. du Sud, all Haiti (all USNM). PUERTO RICO: Bahía de Añasco (MCZ); Punta Algorrobo and Punta Guanajibo (both G. Warmke); Mayagüez (MCZ; G. Warmke). VIRGIN ISLANDS: St. Thomas (MCZ; ANSP; USNM; SDM); Gorda Sound, Virgin Gorda (R. Foster). LESSER ANTILLES: off Fort George, Scarborough, Tobago in 36 fathoms (R. Foster); Pointe à Pierre; La Brea; and Erin, all Trinidad (all MCZ); Port of Spain, Trinidad (ANSP). CARIBBEAN ISLANDS: Curaçao (USNM). MEXICO: Tuxpan, Veracruz (T. E. Pulley); Veracruz, Veracruz (ANSP). COLOMBIA: Cartagena (CAS; USNM); Puerto Colombia (USNM). VENEZUELA: Barcelona (USNM); Campano, Estado Suere (ANSP). BRASIL: Rio de Janeiro (MCZ; ANSP); Praia Grande, Itanhaem, Estado de São Paulo (M. J. Oliveira); Peruhybe, Itanhaem, Estado de São Paulo (H. S. Lopes). URUGUAY: Cape Polonia, Dept. Rocha (USNM). ARGENTINA: Río Negro, Patagonia (USNM).

### *Atrina (Servatrina) serrata* Sowerby.

Plates 170; 171

*Pinna serrata* Solander 1786, Catalogue of the Portland Museum, pp. 71, 165 [nomen nudum].

*Pinna serrata* Sowerby Feb. 1825, Catalogue of Shells of Earl of Tankerville, London, p. 23, appendix, p. v; 'Solander' Sowerby Nov. 1825, The Genera of Recent and Fossil Shells, Liv. 26, **Pinna**, (no locality given); Reeve 1841, Conchologia Systematica 1, pl. 103; Reeve 1859, Conchologia Iconica 11, **Pinna**, pl. 34, fig. 65 (West Indies).

*Pinna squamosissima* Philippi 1849 [in] Roemer, Texas, Bonn, p. 454 (near Galveston, Texas).

*Pinna seminuda* 'Lamarck' Reeve 1858, Conchologia Iconica 11, **Pinna**, pl. 2, fig. 2 (South Carolina); non *Pinna seminuda* Lamarck 1819.

*Pinna muricata* 'Linné' Holmes 1860, Post Pleiocene Fossils of South Carolina, Charleston, S.C., p. 15, pl. 3, fig. 3 (Simmons'; Abbapoola [Abbapoola Creek, Johns Id.], both near Charleston, South Carolina); non *Pinna muricata* Linné 1758.

*Description.* Shell reaching 295 mm. (about 11½ inches) in length, wedge-shaped, inflated, thin, fragile and sculptured with numerous imbricate, radiating ribs. Shell translucent, ranging in color from a light tan to a medium greenish brown. Surface, between the rows of spines, somewhat glistening. Sculpture remarkably uniform for this genus. On the posterior slope it consists of about 30 inconspicuous ribs which are indicated mainly by the imbrications arming them. Sculpture on the ventral slope consisting of concentric growth lines and fine imbrications. Posterior margin usually truncate with a distinct angle at the union of the posterior and ventral slope. Dorsal margin straight to slightly concave. Ventral margin convex posteriorly and concave anteriorly. Interior of the valves iridescent, light tan to greenish brown in color. Nacreous layer thin and usually extending over three fourths the length of the valve. Posterior adductor muscle scar nearly circular in outline and set well within the nacreous layer. Anterior adductor muscle scar small, nearly as wide as the anterior end of the valve.

length	width	
295 mm.	167 mm.	Sanibel, Florida
245	136	Shackelford Id., North Carolina
227	112	12 miles S of St. Augustine, Florida
180	86	Port Isabel, Texas

*Types.* The holotype of *Pinna serrata* Sowerby is in the British Museum (Natural History), no. B3054 from the Tankerville Collection. The type locality is here designated as Charleston, South Carolina, a locality from which a great deal of material was sent to Europe at that time. We are grateful to I.C.J. Galbraith of the British Museum for the figure of the holotype (Plate 170). The location of the type of *Pinna squamosissima* Philippi is unknown to us. The type of *Pinna seminuda* 'Lamarck' Reeve is in the British Museum and that of *P. muricata* Holmes is in the Charleston Museum, Charleston, South Carolina.

*Remarks.* *Atrina serrata* is close in its relationship to *A. seminuda* Lamarck; however, it may be readily distinguished by its thinner shell, more numerous, crowded ribs, and low imbricate spines. In *A. seminuda* the spines are usually tubular and slightly recurved. The posterior adductor muscle scar of *seminuda* is usually smaller, proportionately, than that of *serrata* and the nacreous layer of *seminuda* extends only about one half to two

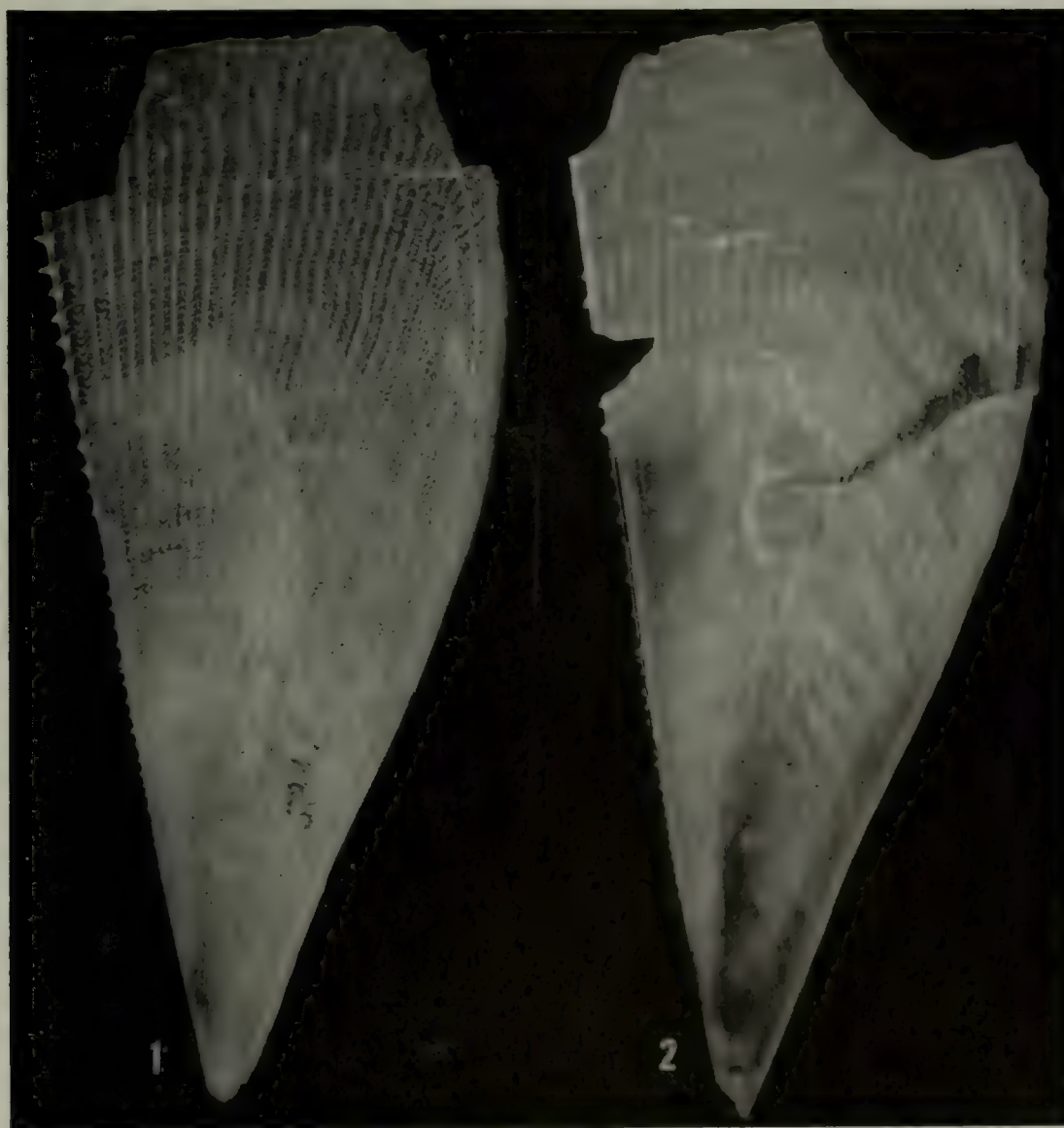


Plate 170. *Atrina* (*Servatrina*) *serrata* Sowerby. Holotype of *Pinna serrata* Sowerby [= *Atrina serrata* Sowerby]. A small, fragile specimen showing the row of spines on the dorsal margin typical of young specimens (natural size). Photograph courtesy of the British Museum (Natural History).

thirds the length of the valve, while that of *serrata* extends at least three fourths the length of the valve. In addition, *A. serrata* is a far more inflated species: a specimen 240 mm. (about 9½ inches) in length had a thickness of 57 mm. (2¼ inches), compared with a specimen of *A. seminuda* of the same length which is only 41 mm. (1⅝ inches) thick when measuring the distance through the apposed valves in the vicinity of the posterior adductor muscle.

*Range.* From Hatteras Inlet, North Carolina, south through the Florida Keys and in the Gulf of Mexico to Texas and south to Colombia. It is apparently rare in the West Indies, having been recorded only from Cuba, Puerto Rico and Trinidad. The paucity of records in Central America is probably due to lack of collecting.

*Specimens examined.* NORTH CAROLINA: Point Buxton, Cape Hatteras (USNM); Hatteras Island, Hatteras Inlet (J. K. Howard); Shackleford Island (MCZ); Fort Macon, Beaufort (USNM); Bogue Island (MCZ); Cape Fear (ANSP). SOUTH CARO-

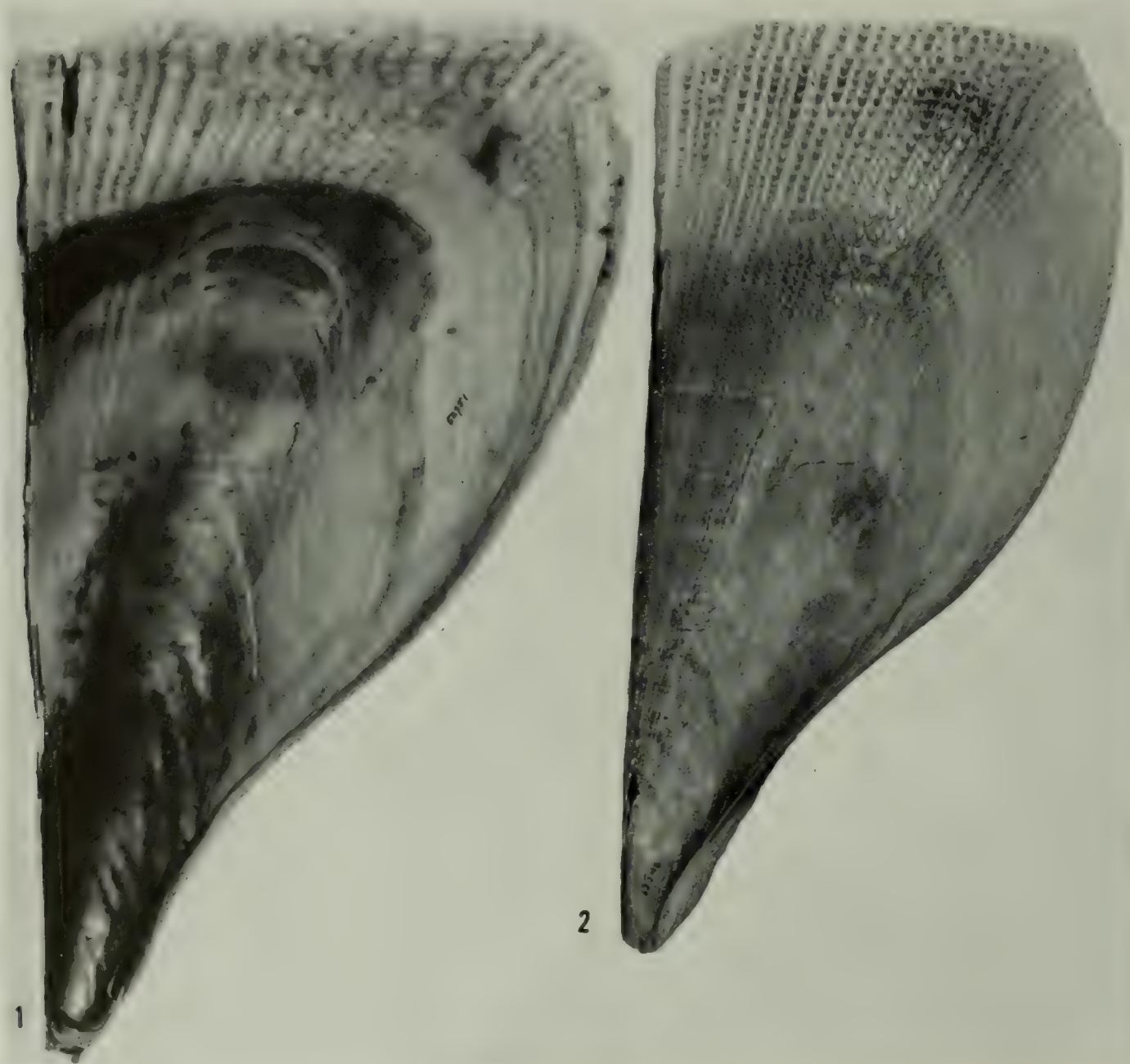


Plate 171. *Atrina* (*Servatrina*) *serrata* Sowerby. Fig. 1. From Mitchell's Beach, Gulfport, Florida. Inner view of valve to show the extent of the nacreous layer and the position of the muscle scar. Fig. 2. From Sanibel Island, Florida. External view of the valve showing the numerous fine, radiating ribs (both about ½ natural size).

LINA: Myrtle Beach (ANSP); Isle of Palms (E. B. Richardson); Charleston (MCZ; USNM); Ashe Island, mouth of Edisto River (ANSP). GEORGIA: Sea Island, Glynn Co. (MCZ; ANSP); St. Simons Island (ANSP; USNM); South Beach, Brunswick (ANSP). FLORIDA: Fernandina (ANSP); Amelia Island (MCZ; ANSP; USNM); Pablo Beach, near St. John River (MCZ; ANSP); Atlantic Beach, near Jacksonville (MCZ); South Beach, Anastasia Island, St. Augustine (ANSP); 12 miles S of St. Augustine (MCZ); 7 miles S of Matanzas River, St. Johns Co. (ANSP); Ormond Beach; Coronado Beach; New Smyrna; Cape Canaveral; off Beacon D, The Elbow, Key Largo in 50 and 100 fathoms; 5 miles SE of Sombrero Light, Marathon, Key Vaca (all MCZ); Cape Romano; Fort Meyers Beach (both ANSP); Sanibel Island (ANSP; MCZ; USNM; SDM; J. Schwengel; G. Kline); Captiva Island (J. Schwengel); Boca Grande, Gasparilla Island (ANSP); Long Key, off Sarasota (MCZ); Anna Maria Key, Sarasota Bay (USNM); Mullet Key, Tampa Bay (ANSP); Pass-a-Grille (CAS); Mitchell's Beach, Gulfport (MCZ); Clearwater Bay (ANSP); Cedar Keys (SDM); St. Joseph's Bay, Calhoun Co. (ANSP); Port St. Joe (MCZ; USNM); Panama City (USNM); Pensacola (SDM). MISSISSIPPI: Horn Island (D. Moore). LOUISIANA: Breton Island (R. Parker); Mississippi Delta (K. Johnstone). TEXAS: Galveston (T. E. Pulley); Matagorda Bay (CAS; USNM); Port Aransas (MCZ; ANSP); Padre Island, near Port Isabel (R. Parker); Port Isabel (E. Weisenhaus). MEXICO: Tuxpan, Veracruz (T. Pulley). COLOMBIA: Cartagena (CAS). PUERTO RICO: Punta Guanajibo, 4 miles S of Mayagüez (G. Warmke). CUBA: Varadero Beach, Matanzas (ANSP). LESSER ANTILLES: off Fort George, Scarborough, Tobago in 36 fathoms (MCZ). Near Erin River, Trinidad (H. G. Kugler).

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\* \* \* \*

## The Works of Georgius Everhardus Rumphius 1626-1693

The work of Rumphius though published in 1705, some fifty-three years prior to the appearance of the tenth edition of Linné's *Systema Naturae*, is of great importance to all malacologists because of the many references which Linné made to it. At the time Linné wrote the tenth edition of the *Systema Naturae* in 1758, the starting point of our binomial system of nomenclature, he did not have in his collection a number of the species which he named in his book. In addition, the *Systema Naturae* was not illustrated and consequently, to aid in the understanding of his species, Linné referred to one or several illustrations in other works. One of those most quoted by Linné was that of Rumphius, D'Amboinsche Rariteitkamer, referred to by Linné as "Rumph. mus." Consequently, in many cases the figures in Rumphius have been selected by subsequent authors as the "type figures" of Linné's species.

Rumphius, or Georg Eberhard Rumpf as his name was known in Dutch, was born in Hanau, a small town in Hesse, Germany in 1626 and apparently moved to Holland. According to Bickmore, Rumphius "having studied medicine, at the age of twenty-eight went to Bavaria, entered the merchantile service of the Dutch East India Company,

and thence proceeded to Amboina, where he passed the remainder of his life. At the age of forty-two, while contemplating a voyage back to his native land, he suddenly became blind and therefore never left his adopted island home; yet he continued to prosecute his favorite studies in natural history till his death, which occurred in 1693, when he had attained the ripe age of sixty-seven." According to Swainson, he was at one time governor of Amboina.

The first edition of his great work on the shells of Amboina "D'Amboinsche Rariteitkamer" or Amboina Curiosities was published in folio edition at Amsterdam in 1705, twelve years after his death, and for many years it was the standard work on the mollusks of this area. Another edition, also in Dutch appeared in 1741 using the same plates. It is this edition that is most commonly seen today. This edition is divided into three parts or books, the first including pages 1-54 and plates 1-16 covered the crustaceans and echinoderms, the second including pages 55-194 and plates 17-49 dealt with the marine mollusks of Amboina and the third, covering pages 195-340 and plates 50-60 described the minerals, stones and artifacts. The illustrations are for the most part good for the time though many of the shells are reversed as some of the illustrations were apparently cut directly on wood blocks and not from a mirror image, a practice which later became universal with all engravers. To make such reversed specimens look natural one should look at them in a mirror.

A German edition of this work entitled "Amboin Raitäten-Kammer" which was translated by Müller and emended by Chemnitz was published in Wien in 1766. In this edition a number of the plates and much of the text were changed. It cannot, therefore, be used in conjunction with Linné's work.

The "Thesaurus Imaginum Piscium Testaceorum, etc." by Rumphius was published in 1711. This book was a folio edition containing 60 plates, the same used in the "D'Amboinsche Rariteitkamer" but the text was reduced to the plate captions and an index.

According to Bickmore, when Holland became a province of France in 1811, attempts were made to make Paris the center of science and literature in Europe and the Rumphius collection was taken from Leyden to Paris. Though it was later returned, much damage had been done to the collection during the two transfers and a large portion of the specimens had disappeared. Louis Agassiz apparently knew of this loss and realized that an understanding of many of Linné's species depended upon a knowledge of the specimens which Rumphius had figured in his great work. Consequently, in 1865 he sent Albert S. Bickmore, one of his students, to Amboina for the express purpose of duplicating the Rumphius Collection. Much of this material is now in the Museum of Comparative Zoölogy.

Rumphius also wrote extensively on the botany of Amboina and he is generally credited with having laid the foundations of botanical and zoological research in the East Indies. During his trip to Amboina, Bickmore located the grave of Rumphius which was marked by a small square pillar erected in 1824 by G. A. Phillipus, the royal governor to replace the original marker which had been destroyed.

Bickmore, Albert S. 1869. Travels in the East Indian Archipelago. D. Appleton and Company, New York, 553 pages, 36 plates.

—RUTH D. TURNER

### *Book Review*

Olsson, A. A., A. Harbison, W. G. Fargo and H. A. Pilsbry 1953. Pliocene Mollusca of Southern Florida with special reference to those from North Saint Petersburg. The Academy of Natural Sciences Philadelphia: Monographs—Number 8, pp. viii+1-457; 65 plates; 2 text figs.; 2 maps. From the time of its discovery in 1938 by A. P. Cales, the Pliocene fossil bed of North Saint Petersburg has been well explored and collected. The site represents the farthest known northwest extension of the Caloosahatchee formation of southern Florida which is well known as a result of the work of Dall in 1890 to 1903. This recent publication is a study of the mollusks, predominantly marine, which have been collected at the St. Petersburg site. Several authors have reported on the material: Part I, by Olsson and Harbison, is a systematic consideration of the Classes Pelecypoda, Scaphopoda and Gastropoda; Part II, on the gastropod family Turridae, was done by Fargo who also gave a summary of the geology of the Saint Petersburg region which is included in the general introduction; Parts III-A and III-B, by H. A. Pilsbry are devoted, respectively, to studies of the gastropod family Vitrinellidae, and the freshwater gastropods and pelecypods.

As noted by Fargo in the introduction to the study, the Pliocene shells of Saint Petersburg were readily distinguished from Recent or Pleistocene specimens in the area because of their distinctive buff or pale reddish color. For this reason placement in geologic time was more certain than it may be in other areas. Mollusks of the Pliocene which also extend into the Recent were found to comprise 32.49% of the species studied from this site. It was pointed out in the introduction that one difficulty in a study of this type is the determination of the actual number of fossil species which extend into the Recent. This is particularly difficult because of the lack of a complete census of the living mollusk fauna of the West Indian and Gulf areas.

The authors have named 10 new genera, 30 subgenera and 1 new section of mollusks. Of the 517 species and subspecies treated in this report, 137 were described as new. This systematic study will be found extremely useful by malacologists interested in either fossil or recent mollusks of the Florida area.

The Pyramidellidae from the Saint Petersburg collection were sent to the U. S. National Museum and were treated by Dr. Paul Bartsch in his 1955 publication: "The Pyramidellid Mollusks of the Pliocene Deposits of North St. Petersburg, Florida"; Smithsonian Miscellaneous Collections 125, no. 2, pp. 1-102, 18 plates.

—JOSEPH ROSEWATER

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## THE GENUS CONUS IN THE WESTERN ATLANTIC

BY  
WILLIAM J. CLENCH

### *Conus fosteri* Clench and Aguayo

*Conus fosteri* Clench and Aguayo 1942, *Johnsonia* 1, no. 6, p. 34, plate 12, fig. 5 (off Sagua la Grande, Santa Clara [Las Villas] Cuba).

*Specimens examined.* VENEZUELA: *Atlantis*, cruise 240, off Cabo Codera (N. Lat. 11°; W. Long. 66°1') in 150 fathoms (W. Athearn).

This extends considerably the range of this species. Heretofore it was known only from Cuba.

## THE GENUS SCONSIA IN THE WESTERN ATLANTIC

BY  
WILLIAM J. CLENCH

### *Sconsia striata* Lamarck

Plate 172

*Sconsia striata* Lamarck. Clench and Abbott 1943, *Johnsonia* 1, no. 9, p. 6.

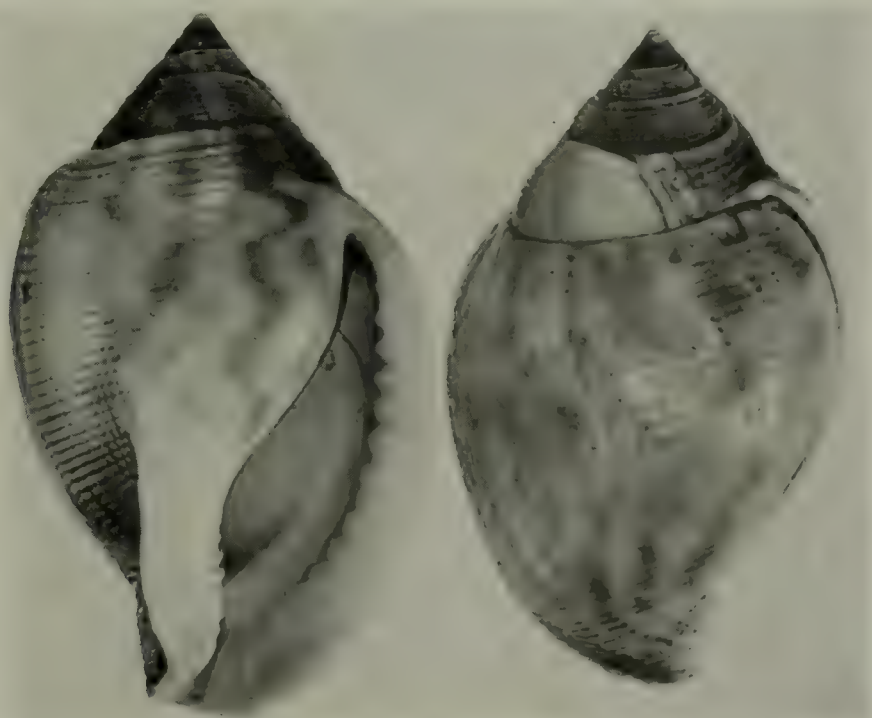


Plate 172. *Sconsia barbudensis* Higgins and Murrat (= *Sconsia striata* Lamarck). Holotype, 15 fathoms, off Barbuda, Lesser Antilles (slightly enlarged).

At the time of our original study of this genus, it was impossible to get photographs from Europe. Through the kindness of Mr. W. K. Ford, Keeper of Invertebrate Zoology of the City of Liverpool Public Museums we have obtained a photograph of the holotype of *Seonsia barbudensis* Higgins and Marrat. This species is a synonym of *Seonsia striata* Lamarck. The measurements of the holotype are: length 67 mm., width 38 mm.

## THE GENUS COLUMBARIUM IN THE WESTERN ATLANTIC

BY  
WILLIAM J. CLENCH

Through the kindness of Mrs. Roy C. Athearn I am privileged to describe the following species. The specimens were obtained by her son, William Athearn during a cruise of the *Atlantis* off the coast of Venezuela.

### *Columbarium brayi*, new species

Plate 173, figs. 1-2

*Description.* Shell medium in size, reaching 51 mm. (2 inches) in length, imperforate, rather thin, dull and carinated. Color a dull light yellowish brown. Whorls 9 and sharply carinated. Spire somewhat depressed. Suture deeply impressed. Aperture subquadrate. Outer lip simple. Parietal wall thinly glazed. Columella long and straight, extending to the end of the long siphonal canal. Sculpture consists of numerous fine, spiral cords which are interrupted by the growth lines. Embryonic whorls two, smooth and glass-like. Periostracum thin with short axial blades. Operculum unknown.

length	width	
51.0	20 mm.	Holotype
37.5	18	Paratype

*Types.* Holotype, Museum of Comparative Zoology, no. 221601, from *Atlantis*, cruise 240, off Cabo Codera, Venezuela (N. Lat. 11°; W. Long. 66°1') in 150 fathoms, W. Athearn collector, Nov. 1, 1957. A single paratype from the same station.

*Remarks.* This species does not appear to be closely related to any other species of *Columbarium* in the Western Atlantic. Its larger size and lack of spines differentiate it from *C. atlantis* Clench and Aguayo, its larger size and depressed spire distinguish it from *C. bermudezi* Clench and Aguayo and its size and smooth carina from *C. sarissophorum* Watson. This last species has a uniformly serrated carina (see *Johnsonia* 1944, 1, no. 15, p. 3).

This species is named for Captain W. Scott Bray of the *Atlantis*.

### *Columbarium atlantis* Clench and Aguayo

*Columbarium atlantis* Clench and Aguayo 1944, *Johnsonia* 1, no. 15, p. 2, pl. 1, fig. 4 off Matanzas, Cuba).

*Specimens examined.* CUBA: *Atlantis*, station 3434, off Sagua la Grande, Las Villas (N. Lat. 23°10'; W. Long. 79°35') in 260 fathoms.



Plate 173. *Columbarium brayi* Clench. Fig. 1. Holotype. Fig. 2. Paratype. 150 fathoms off Cabo Codera, Venezuela (2.8x).

## THE GENUS MUREX IN THE WESTERN ATLANTIC

BY

WILLIAM J. CLENCH

### *Murex (Murex) finlayi* Clench

Plate 174, figs. 1-3

*Murex (Murex) finlayi* Clench 1955, *Breviora*, Museum of Comparative Zoology, no. 44, pp. 1-3, text figs. 1-3 (Matanzas Bay, Cuba).

*Description.* Shell reaching 93 mm. ( $3\frac{3}{4}$  inches) in length, rather solid in structure and moderately spinose. Whorls 10 and moderately convex. Nuclear whorls glass-like and smooth. Color brownish yellow to brownish cream with a few spiral threads of a darker

brown which follow the crests of the cords. Spire moderately extended. Suture irregular and deeply indented. Aperture subcircular and slightly oblique. Parietal lip glazed, adherent to the body whorl and fairly thick. Palatal lip crenulated and slightly thickened. Siphonal canal greatly extended, sometimes nearly half the length of the shell, usually curved upward and to the left when viewed dorsally. Two or three previously formed stages of the siphonal canal remain as scale-like spines. The sculpture consists of three equidistant varices, each supporting a rather large shoulder spine and maybe two or three smaller spines between the shoulder and the base of the shell. The varices on each whorl are more or less aligned with the varices on the whorl above. Between the varices there are two to four axial ridges which are strongly nodulose. Spiral sculpture consisting of numerous thread-like cords. The varices are formed by two arched plates, the plates on the aperture side being somewhat smaller, the outer (first formed) leaving a flange or web-like ridge as a crest on the varix. This is usually broken away on the early varices or remains as a series of small blade-like spines.

length	width	whorls	
87	30	10	Holotype
93	31	10	Paratype
85	33	10	Paratype
82.5	34	10	Paratype

*Types.* Holotype, Museum of Comparative Zoology, no. 189939 from shell trap, Matanzas Bay, Cuba, in 100 fathoms. Paratypes from the same locality in the Museum of Comparative Zoology and the collections of C. J. Finlay and E. H. Monroe.



Plate 174. *Murex (Murex) finlayi* Clench. Figs. 1 and 3. Paratypes. Fig. 2. Holotype. 100 fathoms, Matanzas Bay, Cuba (all slightly enlarged).

*Remarks.* This species appears to be rather closely related to both *Murex antillarum* Hinds and *Murex beaulti* Fischer and Bernardi. From *M. antillarum* it differs by having fewer and much larger axial costae, having fewer spines, and in possessing a webbing along the varices and greatly extended siphonal canal. From *M. beaulti* it differs by having fewer and much larger axial costae, shorter spines, and not having the extensive webbing which characterizes *M. beaulti*. This present species may also be related to *M. aguayoi* Clench and Farfante but it differs from *aguayoi* by being larger, having the diffused brownish yellow coloration, fewer spines, larger axial costae and by having the webbing on the varices.

The development of the webbing and the greatly extended siphonal canal probably allows these mollusks to exist on a rather soft muddy bottom.

The subgenus *Murex* in which this species is included is a very complex group and of very wide distribution in nearly all tropical and south temperate seas.

### ***Murex (Murex) pulcher* A. Adams**

*Murex (Murex) pulcher* A. Adams. Clench and Farfante 1945, *Johnsonia* 1, no. 17, p. 23, pl. 12, figs. 1-4.

*Specimens examined.* BRASIL: *Hassler* Voyage off Salvador (Bahia) in 40 fathoms (S. Lat. 11°49'; W. Long. 37°20') (MCZ).

This record extends the range of this rare species from the Lesser Antilles to the coast of north central Brasil.

### ***Murex (Phyllonotus) pomum* Gmelin**

*Murex (Phyllonotus) pomum* Gmelin. Clench and Farfante 1945, *Johnsonia* 1, no. 17, p. 26, pl. 14, figs. 1-3.

*Specimens examined.* FLORIDA: St. Andrews Bay, Panama City (R. Work). TEXAS: 5 miles W of Rockport (MCZ), Port Aransas (T. Pulley).

### ***Murex (Phyllonotus) pomum margaritensis* Abbott**

Plate 175, figs. 1-2

*Murex imperialis* Swainson 1831, Zoological Illustrations (2) 2, pl. 67 (Island of Margarita [Venezuela]). Non *Murex imperialis* Fischer 1807.

*Murex (Phyllonotus) pomum* Gmelin. Clench and Farfante 1945 [in part] *Johnsonia* 1, no. 17, p. 26.

*Murex margaritensis* Abbott 1958, Acad. Nat. Sci., Philadelphia, Monograph no. 11, p. 61, pl. 1, figs. n and o. [New name for *Murex imperialis* Swainson, non Fischer].

In our *Johnsonia* number on *Murex* (1945, 1, no. 17, p. 26) we considered *Murex imperialis* to be a synonym of *Murex pomum* Gmelin. At that time we had seen no specimens so our judgment was based only upon descriptions and figures in Swainson, Reeve and Kiener, all of whom failed to show the deep pink coloration of the aperture. Abbott has mentioned several characters which distinguish this form from *pomum*. When a series of this form is examined, all of these characters, other than the pink coloration, are found in both *pomum* and *imperialis*. The number of varices on the body whorl vary in both forms, but the variation appears to be similar in both *pomum* and *imperialis*. There are two rows of spines on most specimens of *imperialis* we have seen, not one row as stated by Abbott.

Many specimens of *imperialis* lack the brown patch on the parietal area, but in others it is present. Most specimens of *imperialis* are less attenuated than *pomum*, but even this character is occasionally duplicated in large specimens of *pomum*.

length	width	
96 mm.	70 mm.	Margarita Id.
68	43.5	Erin River, Trinidad

*Range.* Margarita Island, Venezuela east to Trinidad.

*Specimens examined.* VENEZUELA: Margarita Island (MCZ). LESSER ANTILLES: near Erin River; Guayaguagare Beach; Magueripe Bay; Couva Bank, Gulf of Paria, all Trinidad (all H. G. Kugler).

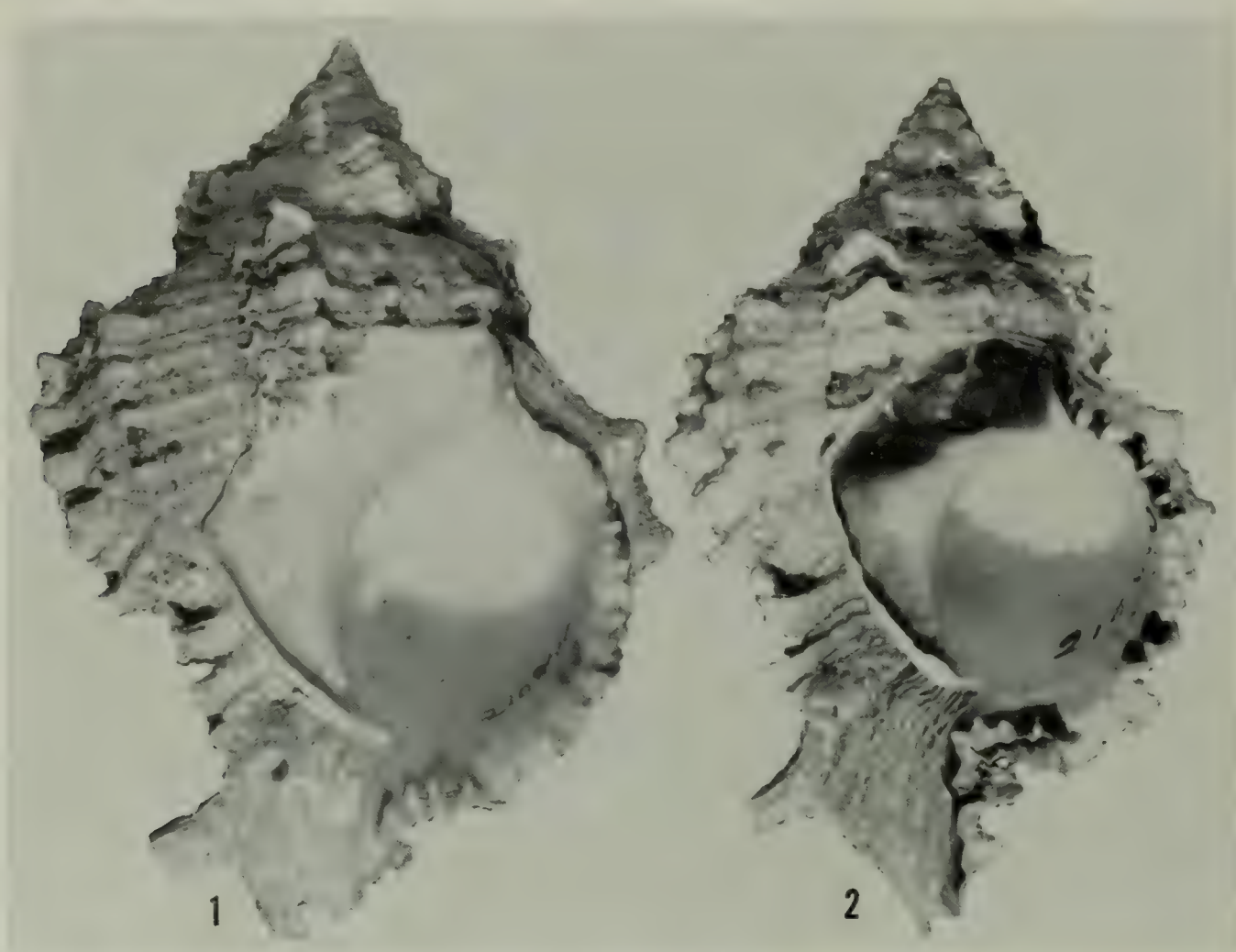


Plate 175. *Murex pomum margaritensis* Abbott. Fig. 1. With a clear pink aperture. Fig. 2. With the brown parietal spot. Margarita Island, Venezuela (about natural size).

## THE GENERA HEMITOMA AND DIODORA IN THE WESTERN ATLANTIC

BY  
RUTH D. TURNER

*Hemitoma* is a small and relatively little known genus in the Fissurellidae. It is close to *Emarginula*, but in *Hemitoma* the anal notch is reduced or lacking but there is an internal anal groove. A key to the genera and subgenera of the Fissurellidae of the Western Atlantic appeared in *Johnsonia* 2, no. 24, p. 94.

Genus *Hemitoma* Swainson

*Hemitoma* Swainson 1840, Treatise on Malacology, p. 356; Iredale 1915, Transactions New Zealand Institute 47, p. 433.

*Submarginula* Gray 1847, Proceedings Zoological Society London 15, p. 147 (type species, *Patella octoradiata* Gmelin, by monotypy).

*Siphonella* Issel 1869, Malacologia del Mar Rosso, p. 232 (type species, *Emarginula* (*Siphonella*) *arconatii* Issel, by monotypy).

*Hemitoma* 'Rafinesque' Scudder 1882, Nomenclator Zoologicus, Part I, Supplemental List. Bulletin United States National Museum, no. 19, p. 159 [error for *Hemiloma* Rafinesque].<sup>1</sup>

Type species, *H.* [*Emarginula*] *tricostata* Sowerby [= *octoradiata* Gmelin], by monotypy.

Shell patelliform, small to medium in size, solid in structure, elliptical to broadly oval in outline, depressed to highly conic. Sculpture consisting of radial ribs and in some species both radial ribs and concentric ridges. Anterior rib usually the most prominent and often with a small notch at the ventral margin. Muscle scar horseshoe shaped with the anterior ends recurved toward the apex as triangular spurs. The scar left by the attached area of the mantle anterior to and between the spurs is probably responsible for the description of the muscle scar in this group as being trilobed. Radula with a moderately wide central tooth which has a single cusp without denticles. The first three lateral teeth are similar but much narrower. The fourth lateral is large, nearly covering the third lateral when in its normal position. At the base of this tooth and between it and the first marginal tooth there is a small squarish plate or tooth which is quite flat except for a central thickened ridge. This plate was first figured by Odhner (1932, fig. 41). This is similar to what Robertson (1958) has shown in the radula of *Tricolia* and referred to as a latero-marginal plate. It is interesting that this structure should appear in two such unrelated groups, or has it been overlooked in other families? The marginal teeth of *Hemitoma* range in number from 30 to over 60, they are long, narrow, with a single cusp and numerous denticles.

Gray 1847 gave credit to de Blainville for the name *Submarginula* with *Patella octoradiata* Gmelin as the type. However, de Blainville used this name only in the vernacular—'Les submarginules.' Though Pilsbry (1891) used *Submarginula* de Blainville 1825 with *Emarginula emarginata* de Blainville as the type species, the first acceptable use of the name is that of Gray 1847. *Hemitoma* Swainson 1840, having seven years priority, is the name generally accepted for this genus today. Iredale (1915, p. 433) has given a detailed discussion of this problem. However, he was in error in using *Submarginula* Gray for *octoradiata* alone, and considering *Hemitoma* a distinct genus with *tricostata* Sowerby as type. This species is a synonym of *octoradiata* and *Submarginula* an objective synonym of *Hemitoma*.

The oldest known American species in this genus is *Hemitoma* (*Hemitoma*) *sciara* which was described by Woodring (1928, p. 475) from the Miocene of Bowden, Jamaica. This

<sup>1</sup> In the Preface to his book Scudder stated: "Where the entry has been furnished by an author or other correspondent his name is appended in *italics* as its sponsor; the name *Agassiz* is appended to all entries copied from his manuscript additions to the Nomenclator of 1846." Such was the case with *Hemitoma* Rafinesque. However, when checking Agassiz' Nomenclator, we find that he had not included *Hemiloma* Rafinesque and it was this to which he was referring in his manuscript and Scudder made the error in copying it.

species is very close to the recent species *H. octoradiata* Gmelin which is common throughout the West Indies. The only fossil records from the mainland are those of *Hemitoma* (*Montfortia*) *retiporosa* Dall (= *emarginata* de Blainville) from the Pliocene of Florida. Wenz (1938) records the genus as first appearing in the Eocene.

Odhner (1932) has discussed the anatomy of *Hemitoma* in relation to the other genera in the Fissurellidae and has illustrated the anatomy of *H. octoradiata*.

This genus is world wide in distribution in warm temperate and tropical seas.

### Subgenus *Hemitoma* Swainson

Species in this subgenus are characterized by having the sculpture predominantly radial, with strong primary and secondary radial ribs. The concentric sculpture is weak, usually consisting only of growth lines. The anal notch is lacking except in some very young depressed forms but the internal anal groove is well marked. The apex is nearly central, usually blunt and inclined only slightly posteriorly.

There is only a single recent species in this subgenus in the Western Atlantic.

### *Hemitoma* (*Hemitoma*) *octoradiata* Gmelin

#### Plates 176, 177

*Patella octoradiata* Gmelin 1791, *Systema Naturae*, ed. 13, p. 3699 (*Insulas Americae mediae*).

*Emarginula tricostata* Sowerby 1824, *The Genera of Recent and Fossil Shells*, no. 21, *Emarginula*, fig. 6 (no locality given).

*Emarginula listeri* Anton 1839, *Verzeichniss der Conchylien*, p. 27 (refers to Lister, pl. 532, fig. 11—Barbados).

*Emarginula clausa* d'Orbigny 1842 [in] Sagra, *Histoire d'Ile de Cuba*, *Mollusques* 2, p. 194, pl. 24, figs. 34-36 (Cuba).

*Subemarginula octoradiata* Gmelin. Gray 1847, *Proceedings Zoological Society London* 15, p. 147; A. Adams 1851 [1852], *Proceedings Zoological Society London*, p. 90; Pilsbry 1891, *Manual of Conchology* 12, p. 273.

*Emarginula depressa* Sowerby 1863, *Thesaurus Conchyliorum* 3, p. 219, pl. 247, figs. 64, 65, 68 (no locality given).

*Emarginula guadaloupensis* Sowerby 1863, *Thesaurus Conchyliorum* 3, p. 219, pl. 247, fig. 69 (Guadeloupe Island, on basis of name).

*Hemitoma octoradiata* Gmelin. Woodring 1928, *Carnegie Institution of Washington Publication*, no. 385, p. 457.

*Hemitoma rubida* A. H. Verrill 1950, *Nautilus* 63, p. 126, pl. 9, figs. 2, 2a (Canefield Point, Dominica, B.W.I.).

**Description.** Shell solid, reaching 30 mm. (1¼ inches) in length, patelliform and radially sculptured. Extremely variable in shape, ranging from nearly circular to elliptical in outline, the height varying from about ¼ to nearly the length of the shell. Apex sub-central and pointed slightly posteriorly. Anterior slope slightly to strongly convex. Posterior slope slightly concave immediately below the apex, then varying from nearly straight to rather strongly convex. Radial sculpture consisting of eight unbranched, irregularly nodulose primary ribs which extend from the apex to the basal margin. In young specimens the primary ribs are very prominent and project beyond the margin producing a stellate appearance. As the shell grows, secondary and often tertiary ribs are produced between the primary ribs, and the margin becomes finely crenulate. Concentric sculpture consisting of irregular growth lines only. Color a light tan or gray to greenish brown. Periostracum thin, medium golden brown in color and usually seen only

on young specimens. Interior of shell a glossy olivaceous green to purplish brown with a white margin and a white area at the apex. Anal groove narrow and deep, extending inward about  $\frac{1}{2}$  to  $\frac{2}{3}$  the length of the anterior slope.

The soft parts of this species are extraordinarily beautiful. The main portion of the mantle and foot are a medium blue-green, the base of the foot being somewhat lighter. This coloration increases to an intense turquoise near the edge of the mantle, while the edge proper is a vivid magenta. The base of the tentacles and the head are also turquoise while the ends of the tentacles and a circle around the end of the proboscis are magenta.

The radula is similar to that of *emarginata* though the central tooth is somewhat broader and there are far more marginal teeth, there being from over 45 to 60 marginals depending upon the age and size of the specimen.

length	width	height	
18.5 mm.	12 mm.	7.5 mm.	Arthurs Town, Cat Island, Bahama Ids.
23.5	20	20	" " " " " "
19	15	13	Whitehouse, Jamaica
23	23	15.5	" "
22	18	8	Barbados
30.5	24.5	15.2	"
24.5	20	9	Clifton Harbour, Union Island, Grenadines
29.5	25	11.5	Tortugas, Florida

*Types.* *Patella octoradiata* Gmelin as originally described was a composite species. Gmelin's description applies quite well to this species, but the references are certainly composite. His first reference was to Lister, plate 532, fig. 11 and this was used by A. Adams in 1852 to indicate Gmelin's species. Pilsbry followed Adams and selected

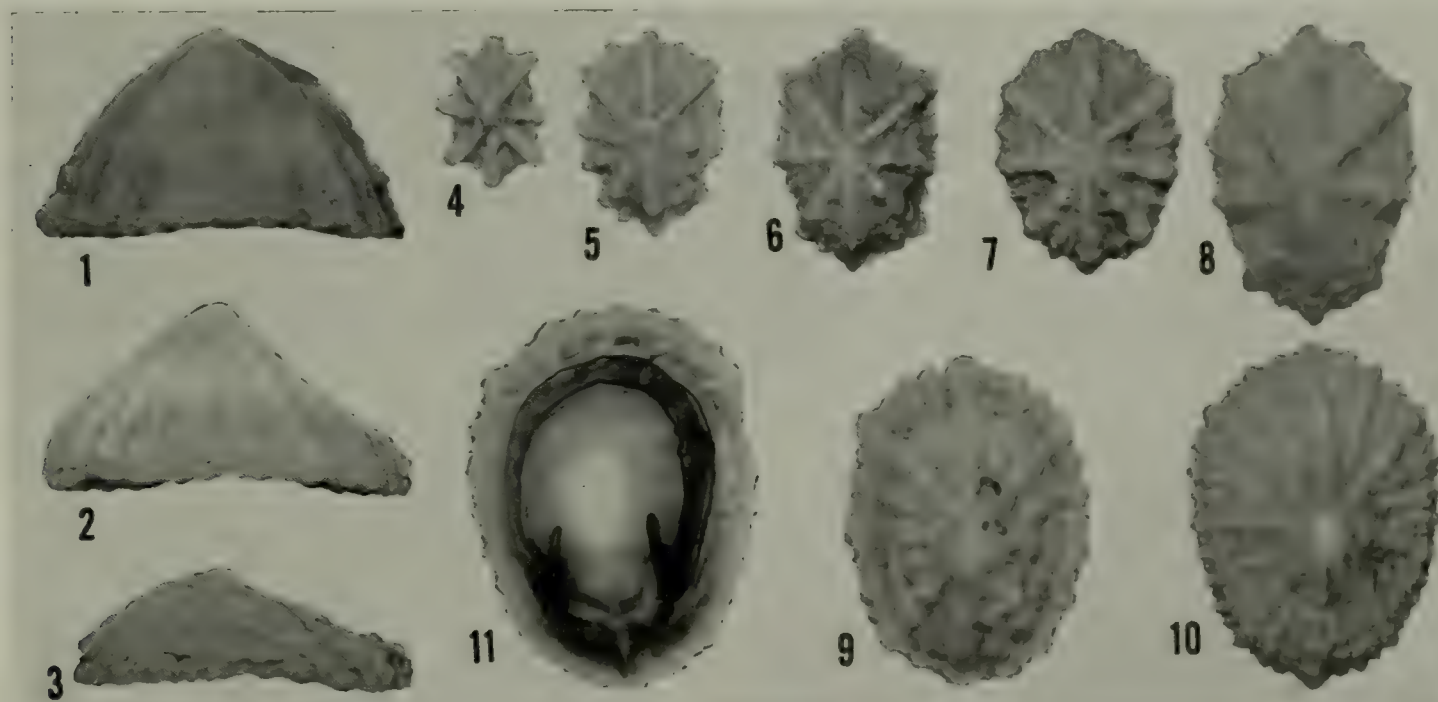


Plate 176. *Hemitoma octoradiata* Gmelin. Series of specimens selected to show variation in shape and sculpture. Fig. 1. Marina Cay, south of Great Camanoe Island, Virgin Islands. Fig. 2. Cayo Francés, Caibarién, Cuba. Fig. 3. Clifton Harbour, Union Island, Grenadines. Figs. 4-7. Cienfuegos Harbor, Cuba. Fig. 8. Dundas Town, Great Abaco, Bahama Islands. Fig. 9. Clifton Harbour, Union Island, Grenadines. Fig. 10. Santa Bárbara de Samaná, Dominican Republic. Fig. 11. Internal view, Marina Cay, south of Camanoe Island, Virgin Islands.

Figs. 1-3. Side view to show variation in height (anterior to the left). Figs. 4-10. Dorsal view to show growth series (anterior end downward). Fig. 10. A specimen with numerous radial ribs (all  $1\frac{1}{2}x$ ).

Lister's figure as the type. As Gmelin gave a very indefinite locality for this species, the type locality is here restricted to Barbados, the locality given on Lister's figure. The type of *Emarginula clausa* d'Orbigny is in the British Museum according to Gray (1854). The types of *E. guadaloupensis* Sowerby and *E. depressa* Sowerby are also probably in the British Museum (Natural History).

*Remarks.* This is an extremely variable species as indicated in the description. Specimens may range from those which are quite flat and nearly circular in outline with strong ribs and deeply crenulated margins to those which are very high and conical with weak ribs and nearly smooth margins, and there may be any combination of these characters. As shown in the measurements, the length of mature specimens may vary in relation to the height from 1.15 to 2.75 and the width may vary from less than  $\frac{2}{3}$  the length to equal the length. *Hemitoma rubida* Verrill is one of the flattened, broad and strongly sculptured types. The anterior rib is usually the most prominent, but this is not always so and the anal groove which follows it on the internal surface of the shell usually does not end in a notch at the margin though in occasional young specimens there may be a very small one. Young specimens are usually somewhat rectangular in outline, depressed and stellate. Specimens of this species are usually moderately to heavily encrusted with

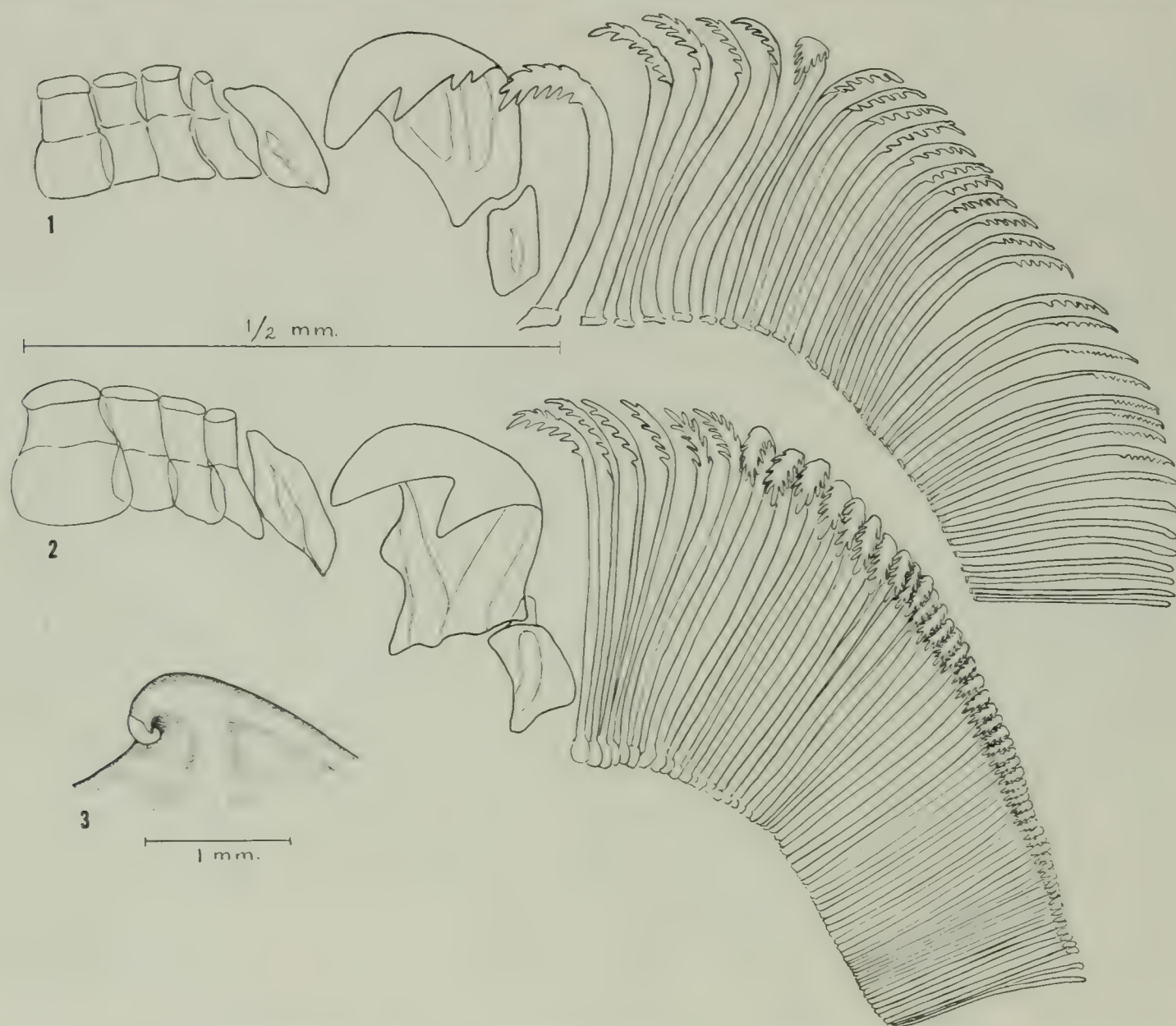


Plate 177. Radulae of *Hemitoma*. Fig. 1. *Hemitoma emarginata* de Blainville. Fig. 2. *Hemitoma octoradiata* Gmelin. Fig. 3. Embryonic whorls of *H. emarginata* de Blainville.

coralline algae and other growths and it is often necessary to clean them in order to study the sculpture. However, the muscle scar, the anal groove and the color pattern on the inner surface are usually sufficient for identification.

Robert Robertson who has spent a great deal of time collecting and studying in the Bahama Islands writes as follows concerning this species. "In the Bahama Islands *H. octoradiata* is abundant in the vicinity of Elbow Cay, Great Abaco (the windward edge of the Little Bahama Bank). It usually lives a few inches below low tide mark on exposed rocky shores. The irregular surface of the rock is covered with lithothamnia (chiefly *Porolithon*) and in this these limpets form slight depressions. They appear to be sedentary. They may also be found under slabs of dead coral (*Acropora*) in the reef northeast of Elbow Cay. Occasionally specimens were found under rocks and live corals in shallow water in sheltered areas. At Bimini, on the leeward side of the Great Bahama Bank, this limpet is scarce. The rocky shores here are not as exposed as many of those at Abaco. Feces of this *Hemitoma* studied at Bimini contained chiefly green algae but also a copepod and series of marginal teeth from its own radula."

*Range.* From Biscayne Bay, Florida south through the Florida Keys, Bermuda (Peile 1926), the Bahama Islands, throughout the West Indies and along the north coast of South America south to Porto Seguro, Brasil.

*Specimens examined.* FLORIDA: Biscayne Bay (MCZ); Pelican Shoals off Boca Chica Key (J. Schwengel); Middle Sambo Shoals, near Key West (T. McGinty); Sand Key, Key West; Dry Tortugas (both MCZ). BAHAMA ISLANDS: West End and Eight Mile Rock, Grand Bahama (both MCZ); Cooper Jacks Cays, S of Elbow Cay and Dundas Town, Great Abaco; North Rabbit Cay, Bimini Islands (all R. Robertson); Brown's Point, New Providence; Governors Harbour, Eleuthera; Cape St. Maria; Clarence Town and Simms, all Long Island; Little San Salvador and Russell Creek, Cat Island; Rum Cay; Matthew Town, Great Inagua (all MCZ). CUBA: Vedado and Playa de Jibacoa, Habana; Cayo Cruz del Padre and Peninsula de Hicacos, Matanzas (all MCZ); Cayo Francés, Caibarién, Las Villas; Santa Maria Key, off Punta Alegre, Camagüey (both R. Humes); Vita; Guarda la Vaca, Banes; Bahía de Banes; Blue Beach, Guantánamo Naval Base, all Oriente; Punta de los Colorados, Cienfuegos, Las Villas (all MCZ). JAMAICA: Runaway Bay, St. Ann's; Montego Bay (both MCZ); Whitehouse (J. K. Howard). HISPANIOLA: Gonave Island, Haiti (W. J. Eyerdam); Monte Cristi; Puerto Plata; Puerto Sosúa; Santa Bárbara de Samaná, all Dominican Republic (all MCZ). PUERTO RICO: Mata de la Gata, off La Paguera; E of Boca de Congrejos (both MCZ). VIRGIN ISLANDS: Virgin Gorda; Marina Cay and Guana Island, Tortola (all M. W. Dewey); St. John; Great St. James Island, St. Thomas (both MCZ); Ham Bay, St. Croix (M. K. Jacobson). LESSER ANTILLES: Antigua; Guadeloupe; Marigot, St. Lucia (all MCZ); Barbados (P. G. Kellett); Carriacou Island, Grenadines; Grand Anse, Grenada (both H. G. Kugler); Buccoo Reef, Tobago (MCZ); Toco, north coast of Trinidad (H. G. Kugler). CARIBBEAN ISLANDS: Southwest point; Grand Cayman, Cayman Islands (MCZ). BRITISH GUIANA: Mouth of Corentyne River (H. G. Kugler). BRASIL: Porto Seguro (MCZ).

### Subgenus *Montfortia* Récluz

*Montfortia* Récluz 1843, Revue Zoologique par la Société Cuvierienne 6, p. 259 and 376.

Type species, *Emarginula australis* Quoy and Gaimard, subsequent designation, Iredale 1915.

Species in this subgenus are characterized by having a pronounced radial and concentric sculpture with the three anterior ribs usually strongest and by having a small anal notch at the margin of the anterior rib in addition to the internal anal groove. The apex is prominent, subcentral and recurved posteriorly.

### *Hemitoma emarginata* de Blainville

Plates 177, 178

*Emarginula emarginata* de Blainville 1825, Manuel de Malacologie, p. 501, pl. 68 bis, fig. 3 (no locality given).

*Emarginula octoradiata* 'Gmelin' Sowerby 1863, Thesaurus Conchyliorum 3, p. 219, pl. 247, fig. 66 (no locality given); non *octoradiata* Gmelin 1791.

*Subemarginula retiporosa* Dall 1903, Transactions Wagner Free Institute Philadelphia 3, pt. 6, pl. 55, fig. 3; pl. 60, fig. 17 (Pliocene marl of Shell Creek, Florida). Figured but not described.

*Hemitoma retiporosa* Dall. Olsson and Harbison 1953, Academy Natural Sciences, Philadelphia, Monographs, no. 8, p. 360, pl. 48 [not 18], figs. 14, 14a.

*Emarginula ostheimeræ* Abbott 1958, Academy Natural Sciences, Philadelphia, Monographs, no. 11, p. 18, pl. 1, fig. c (Old Man Bay, north side of Grand Cayman Island, Cayman Islands).

*Description.* Shell solid, reaching 25 mm. (1 inch) in length, patelliform and strongly sculptured. Extremely variable in shape, the basal outline ranging from more or less quadrate to broadly oval, circular or elliptical. Height ranging from about 1/4 to over 3/5 the length of the shell. Apex subcentral, recurved posteriorly and slightly to the left. Anterior slope convex. Posterior slope concave just below the apex, then continuing nearly straight or slightly convex. Sculpture consisting of radial ribs and concentric ridges with nodules formed where the radial ribs and concentric ridges cross, producing a strong reticulate sculpture. Primary ribs 8 to 10, the anterior rib always being single, usually prominent and ending in a small notch at the margin. The remaining primary ribs may be single or compound, the compound ones made up of from 2 to 5 closely spaced ribs which give the effect of a single broad rib. The spaces between the primary ribs have from 1 to 5 low secondary ribs. Concentric sculpture consisting of more or less evenly spaced ridges, the distance between them increasing slightly as the shell grows. Margin of mature specimens usually moderately to finely crenulate. Young specimens have a strongly scalloped margin. Shell white, periostracum thin, pale yellow and usually remaining only in the pits formed by the reticulated sculpture. Interior of the shell glossy white, often with yellow patches indicating the pits. Anal groove fairly deep and narrow near the margin, ending in a small notch. It extends as a very shallow groove to near the apex. Embryonic whorls one and one half, small, smooth and with a light brown periostracum.

length	width	height	
11 mm.	7.3 mm.	3 mm.	Arenas de la Chorrera, Habana, Cuba
20	15	7	Jamaica
21.5	12	12	Fort Jefferson, Tortugas, Florida
23.5	17	8.2	St. Thomas, Virgin Islands
24.5	18.5	7.2	Off Fowey Rocks, Florida
25.2	19	8.2	Nassau, New Providence, Bahama Islands
25.5	15	12.5	Dry Tortugas, Florida

*Types.* The location of the type specimen of *Emarginula emarginata* de Blainville is unknown.

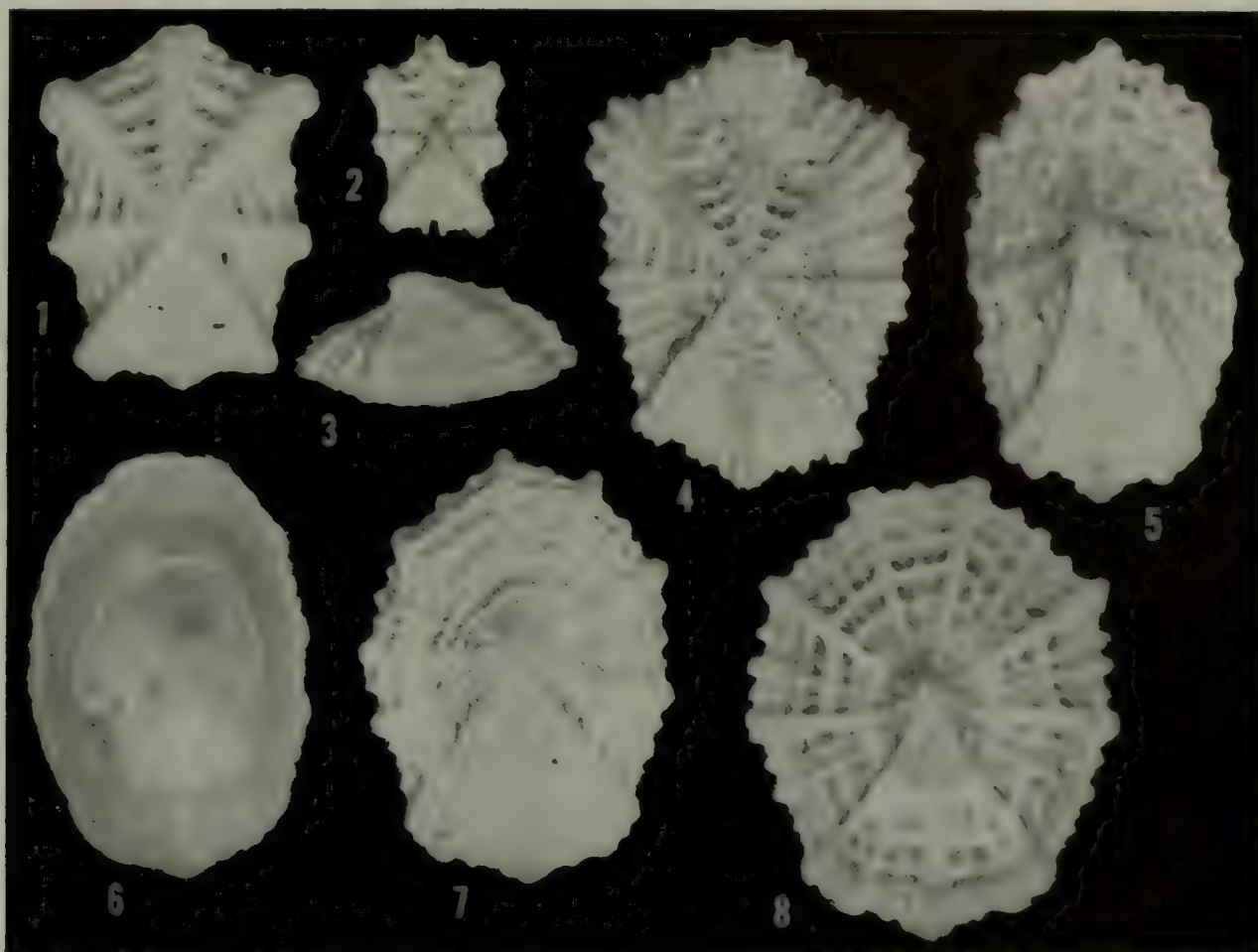


Plate 178. *Hemiloma emarginata* de Blainville. A series to show variation in shape and sculpture (anterior end downward). Fig. 1. Jamaica, a somewhat beachworn specimen. Fig. 2. Arenas de la Chorrera, Habana, Cuba. A young specimen with a distinct anal notch. Fig. 3. Tortugas, Florida, a side view to show average shape in profile (figs. 1, 2 and 4 are somewhat flatter than this; figs. 7 and 8 are about the same and fig. 5 is much higher). Fig. 4. Fowey Rocks, Florida, from an old wreck. Fig. 5. Dry Tortugas, Florida, a very high narrow form. Fig. 6. Barbados, internal view to show muscle scar and anal groove. Fig. 7. St. Thomas, Virgin Islands. Fig. 8. Nassau, New Providence, Bahama Islands, from a pier. (All about 2x.)

The holotype of *Subemarginula retiporosa* Dall is in the United States National Museum and that of *Emarginula ostheimeræ* Abbott is in the Academy of Natural Sciences, Philadelphia, no. 195983.

*Remarks.* This is a rather rare species and specimens are seldom taken alive. Consequently we know nothing of its ecology. It apparently lives from just below low tide to depths of perhaps 100 fathoms. Specimens known to have been collected alive which we have seen, came from a wharf at Nassau, New Providence, Bahama Islands and from a wreck on Fowey Rocks, Florida. On the basis of the poorly preserved specimen available

for study, the anatomy of *emarginata* appears to be very close to that of *octoradiata* and the radula differs mainly in the width of the central tooth and the fewer marginal teeth.

*Emarginula ostheimeræ* Abbott appears to be a young specimen of this species, the type specimen being almost identical with figure 2 shown in the growth series on Plate 178. Dall figured but never described this species from the Pliocene marl of Shell Creek, Florida under the name of *Subemarginula retiporosa*, and Olsson and Harbison report it under *Hemitoma retiporosa* Dall as fairly common in the Pliocene of St. Petersburg, Florida.

The range of variation in this species is equally as great as that in *octoradiata*. Many of the high specimens are also laterally compressed and, as pointed out by Pilsbry (1891), the anterior and posterior ends of many specimens are slightly raised so that the specimen will rock when placed on a flat surface. However, this certainly does not hold true for all specimens. The extent of the anal groove also varies considerably and is barely visible in some specimens.

This species is not closely related to any other found in the Western Atlantic. It differs from *octoradiata* in having a pronounced reticulate sculpture and compound ribs.

*Range.* From Lantana, Florida south through the Florida Keys and probably throughout the West Indies.

*Specimens examined.* FLORIDA: off Lantana in 10 fathoms; off Hollywood in 35–60 fathoms; off Cape Florida, Biscayne Bay in 50 feet; Fowey Rocks;  $5\frac{1}{2}$  miles NE of Beacon D, The Elbow, Key Largo in 66–83 fathoms; 6 miles SE of Sombrero Light, off Marathon in 66 fathoms (all MCZ); Pelican Shoals, Key West in 45 fathoms (J. Schwengel); Fort Jefferson, Tortugas (MCZ). BAHAMA ISLANDS: W of Picquet Rocks, Bimini Islands in 10 fathoms (R. Robertson); Northeast shore of New Providence (D. H. Brown); Nassau, New Providence; Matthew Town, Great Inagua (both MCZ). CUBA: near Habana (MCZ). VIRGIN ISLANDS: St. Thomas (MCZ). LESSER ANTILLES: Barbados (MCZ); Fontenary Beach, Grenada (H. G. Kugler).

### Genus *Diodora* Gray

*Diodora* Gray. Farfante 1943, *Johnsonia* 1, no. 11, pp. 1–20, pls. 1–6.

The following description of *Diodora fragilis* is basically a translation of the work of I. P. Farfante and D. L. Henríquez which appeared after *Johnsonia*, no. 11 on *Diodora* had been published.

### *Diodora fragilis* Farfante and Henríquez

Plate 179, figs. 1–4

*Diodora delicata* Farfante and Henríquez 1946, Revista de la Sociedad Malacologica 'Carlos de la Torre' 4, p. 54 (Arenas de La Chorrera, Habana, Cuba).

*Diodora fragilis* Farfante and Henríquez 1947, *ibid.* 5, p. 52, figs. 1–4 (new name for *D. delicata* Farfante and Henríquez, non E. A. Smith 1889).

*Description.* Shell small, reaching 10 mm. in length, delicate in structure, depressed conic, and with the anterior slope considerably shorter than the posterior slope. Base oval. Anterior slope straight for its entire length, the posterior slope concave just below

the apex, the remainder straight to convex. Apex anterior of the center and pierced by the anteriorly directed orifice. Orifice small, 1 mm. in length and oval. Radial sculpture consisting of numerous rather large, rounded ribs which alternate with very fine ones. Concentric sculpture consisting of numerous lamina which cross the radial ribs forming small scales. Margin denticulate. Color grayish white. Interior of shell gray, glossy and with a series of grooves which correspond to the radial ribs. The callus around the orifice gray, sharply truncated and excavated posteriorly.

length	width	height	
20 mm.	11 mm.	5 mm.	Holotype

*Types.* The holotype is in the collection of Mrs. E. G. Henríquez. The type locality is from sands dredged near Habana and deposited at La Chorrera.

*Range.* Known only from the type locality.

*Remarks.* This is a very distinctive species and readily distinguished from all others known in the Western Atlantic. It belongs to the group of *D. aguayoi* and *D. wetmorei*, but is nearer to *aguayoi*. It differs from that species by having a smaller, broadly oval rather than oblong orifice and is lacking the rounded tooth on either side of the orifice. In addition, the shell of *fragilis* is more depressed, the radial ribs lower and more widely spaced than in *aguayoi*.

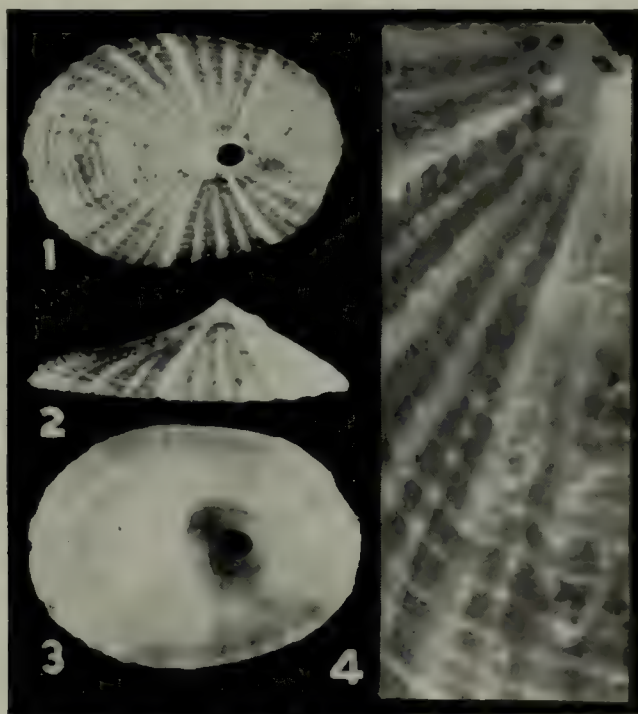


Plate 179. *Diodora fragilis* Farfante and Henríquez. Holotype. Arenas de la Chorrera, Habana, Cuba. Figs. 1-3 ( $2\frac{1}{2}x$ ). Fig. 4 ( $10x$ ).

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\* \* \* \*

## THE GENERA AMAEA AND EPITONIUM IN THE WESTERN ATLANTIC

BY

RUTH D. TURNER

### *Amaea* (*Amaea*) *mittelli*

*Amaea* (*Amaea*) *mittelli* Dall. Clench and Turner 1950, *Johnsonia* **2**, p. 243, pl. 106, figs. 5-7.

*Specimens examined*. TEXAS: Mustang Island, 1 mile S of Port Aransas (Doil Turner).

### *Epitonium* (*Asperiscala*) *sericifilum* Dall

*Epitonium* (*Asperiscala*) *sericifilum* Dall. Clench and Turner 1952, *Johnsonia* **2**, p. 317, pl. 152.

Mrs. G. R. Hettick has kindly donated a specimen of this rare species to the Museum of Comparative Zoology. Dall (1889, p. 124) in his list of the Marine Mollusks of the Southeastern Coast lists this species with a question as occurring on the Texas Coast. The specimen collected by Mrs. Hettick is from 10 miles south of Port Aransas, Texas. It has 10 whorls and measures 6.5 mm. in length and 1.9 mm. in width.

## THE FAMILY PHASIANELLIDAE IN THE WESTERN ATLANTIC

BY

ROBERT ROBERTSON

Some additional observations on *Tricolia* made at the Lerner Marine Laboratory, Bimini, Bahama Islands in June and July, 1958, are included in this supplement, as well as some new records from Cuba. Previously there were no records of *Tricolia* on the south coast of Cuba west of Guantánamo. The specimens were sent by Dr. C. G. Aguayo, Museo Poey, Universidad de la Habana and Dr. Cortez Hoskins, Jersey Production Research Co., Tulsa, Oklahoma.

### *Tricolia affinis affinis* C. B. Adams

*Tricolia affinis affinis* C. B. Adams. Robertson 1958, *Johnsonia* **3**, no. 37, p. 262.

*Specimens examined*. CUBA: Cayo Inés de Soto; Playa Manimaní, both Pinar del Río; Vedado; Arenas de la Chorrera, both Habana; Gibara, Oriente (all Museo Poey); W of Cayo Tablones, Archipiélago de los Canarreos, Habana; Cayo Perro, Cayos de San Felipe (both C. Hoskins); Pta. de la Yana, both Pinar del Río (Museo Poey).

***Tricolia adamsi Philippi***

*Tricolia adamsi* Philippi. Robertson 1958, *Johnsonia* 3, no. 37, p. 268.

*Specimens examined.* CUBA: Vedado, Habana (Museo Poey).

***Tricolia thalassicola Robertson***

*Tricolia thalassicola* Robertson 1958, *Johnsonia* 3, no. 37, p. 271.

*Remarks.* The median longitudinal furrow is present at the anterior end of the under side of the foot only. Hence the waves of progression are only partially ditaxic. There are irregular yellowish olive-green spots, somewhat as on the shell, on the upper surface of the foot. The left cervical lobe is pedunculate and digitate, with four digits in two specimens and three in another. The lobe on the right side is entire.

This species lives on Manatee Grass (*Cymodocea manatorum* Ascherson) as well as on Turtle Grass (*Thalassia*) at Bimini. It was seen to feed on fine filamentous and crustose calcareous red algae.

*Specimens examined.* CUBA: Cayo Inés de Soto; Playa Manimaní, both Pinar del Río; S coast Camagüey Province (subfossil; all Museo Poey); Cayo Perro, Cayos de San Felipe (C. Hoskins); Pta. de la Yana, both Pinar del Río (Museo Poey).

***Tricolia bella M. Smith***

*Tricolia bella* M. Smith. Robertson 1958, *Johnsonia* 3, no. 37, p. 274.

*Remarks.* There is no median longitudinal furrow on the under side of the foot in this species, as was previously stated to be characteristic of the whole genus (p. 250) and the waves of progression are monotaxic, not ditaxic (see also *Remarks* above on *T. thalassicola*). The earlier observation (p. 249) that there is no cervical lobe on the right side was based on a single abnormal specimen. Normally there is an entire lobe, as in *T. thalassicola*. The left lobe had three digits in the specimens examined. The feces are U-shaped, as in *T. pullus*.

Four young specimens (the largest 1.8 mm. long) were collected from floating *Sargassum* west of Bimini. This species usually lives in mats of filamentous green algae. Sometimes it may be found in the red alga *Bostrychia* [= "*Amphibia*"] *tenella* (Vahl) Agardh on mangrove roots.

*Specimens examined.* CUBA: Vedado, Habana (Museo Poey); Cayo Perro, Cayos de San Felipe, Pinar del Río (C. Hoskins).

***Tricolia tessellata Potiez and Michaud***

*Tricolia tessellata* Potiez and Michaud. Robertson 1958, *Johnsonia* 3, no. 37, p. 277.

*Range.* This species was previously believed not to occur on the coast of Cuba. It has, however, been collected on the south coast in a subfossil state. A record of this species at Grand Cayman (Abbott 1958, Academy of Natural Sciences of Philadelphia Monograph 11, p. 32) is based on a specimen collected alive of the banded form of *T. thalassicola* (see Plate 146, fig. 3, p. 272).

*Specimens examined.* CUBA: S coast Camagüey Province (subfossil: Museo Poey).

#### ADDITIONS AND CORRECTIONS

Page 280. The Carpenter specimens of *Tricolia compta* (Gould) are now at the United States National Museum, Washington, D.C.

Page 280. *Phasianella concolor* C. B. Adams is probably a synonym of *Assiminea succinea* (Pfeiffer) [*Paludina succinea* Pfeiffer 1840]. *Paludestrina auberiana* d'Orbigny is not an *Assiminea* as was believed by Dall, but a *Littoridina*.

Page 280. A. Heilprin 1893 (The Bermuda Islands, Philadelphia, p. 175) reports "Phasianella Kochi, Phil." from Bermuda. He evidently had some other species of *Tricolia*, for *T. kochii* (Philippi) is restricted to South Africa (and possibly parts of the Indo-Pacific). There are three separate records of *Tricolia* from Bermuda published during the last half of the nineteenth century and there is only one specimen of *T. bella* in the Haycock Collection, Bermuda Government Museum (*teste* Richard W. Foster). None of the species appear to have been collected in recent years. Evidently the genus is sporadic there.

\* \* \* \*

#### Notes

Since the publication of *Distorsio* in this volume (pp. 235-242) we have obtained two additional records of note.

#### *Distorsio (Rhysema) clathrata* Lamarck

*Specimen examined.* NORTH CAROLINA: *Combat*, station 381, about 15 miles SE of Cape Hatteras (N. Lat.  $34^{\circ}59'$ ; W. Long.  $75^{\circ}33'$ ) in 45 fathoms.

#### *Distorsio (Rhysema) mcgintyi* Emerson and Puffer

*Specimen examined.* BERMUDA:  $\frac{3}{4}$  mile S of Castle Rock in 80-100 fathoms (Bermuda Biological Station).

This record extends the range considerably to the north.

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BY

MERRILL E. CHAMPION

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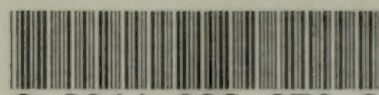
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